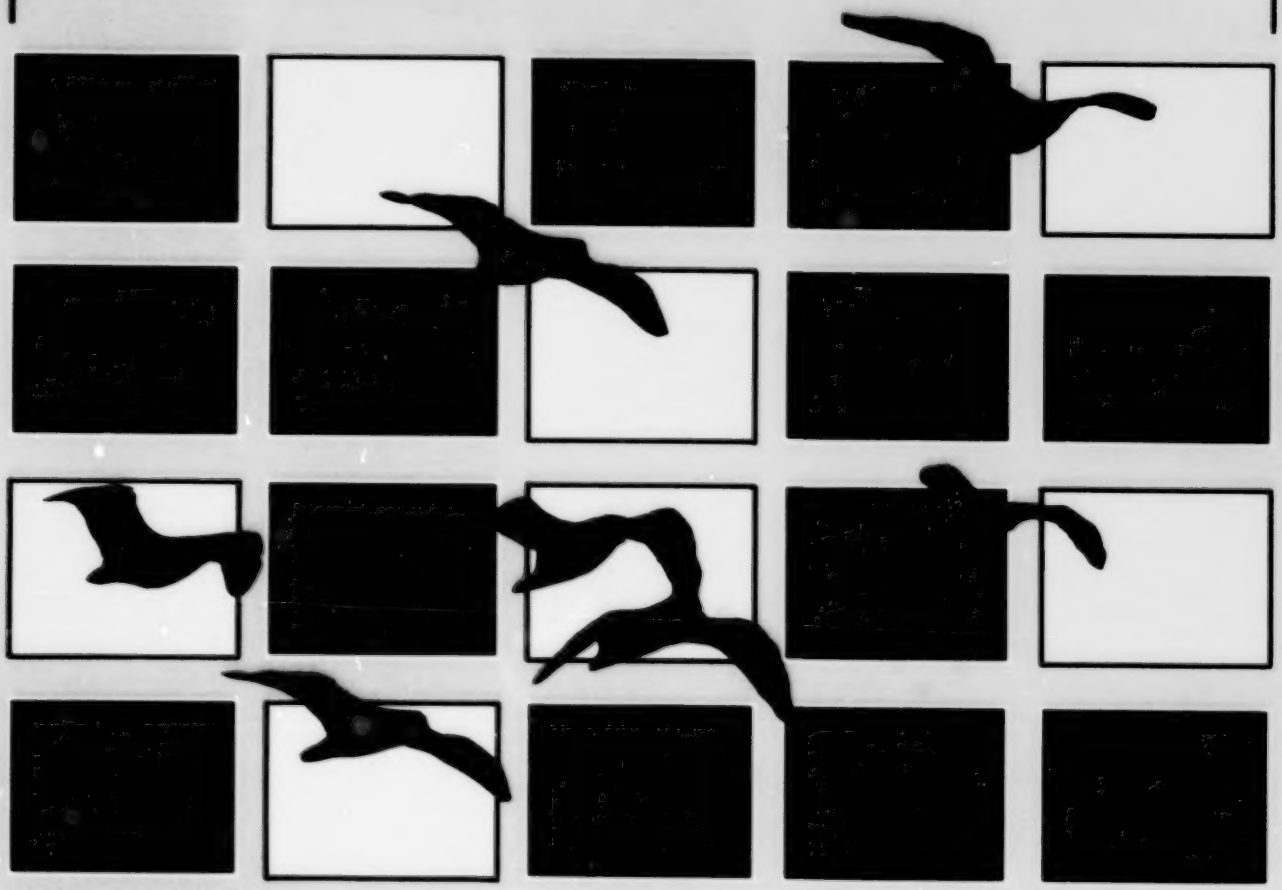
Revised Atlas of Eastern Canadian Seabirds

I. Shipboard Surveys by R.G.B. Brown



Canadian Wildlife Service

Environment Canada
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Service canadien de la faune

Revised Atlas
of Eastern Canadian Seabirds

I. Shipboard Surveys by R.G.B. Brown[1]

Canadian Wildlife Service
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Dartmouth, NS

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Summary

This *Atlas* summarizes quantitative information on seabird distributions, based on standardized observations made off eastern Canada by shipboard observers, between 31 March 1969 and 31 December 1983. It is an updated version of the pelagic aspects of the Canadian Wildlife Service (CWS) *Atlas of eastern Canadian seabirds* (Brown *et al.* 1975*a*), using a new computer-mapping program and a greatly enlarged data base.

The area covered lies north of 40°N and west of 40°W, and includes the Gulf of St. Lawrence and the waters off the Atlantic provinces, the eastern Canadian Arctic, and west Greenland. Many of the observations were collected through PIROP (Programme intégré de recherches sur les oiseaux pélagiques), set up in 1969 by the University of Moncton and CWS, and now organized by CWS, Atlantic Region. Others were made by consultants in the course of environmental surveys commissioned by the offshore oil industry.

The revised *Atlas* is intended to give an overall view of what is known of seabird distributions off eastern Canada for use in offshore environmental assessments. Two basic map formats are used. The *Atlantic* maps cover distributions south of 60°N, and show the average numbers of birds per linear kilometre in each 30′N × 1°W block, seen from ships travelling at more than 4 knots (7.4 km/h). Because of the narrowing of the longitudes at high latitudes, the *Arctic* maps, north of 60°N, use 1°N × 2°W blocks. The averages are plotted as symbols here, but the plotting of actual numbers is an alternative. Where the data are sufficient, each species is represented by maps which show its breeding distribution (based on data in the original *Atlas*), its pelagic distribution in the Atlantic in January–March, April–June, July–September, and October–December, and in the Arctic in July–August and September–October. Maps with a more restricted seasonal or geographical scope can be generated to fit individual requirements; to show seabird distributions in the immediate vicinity of a drill site, for example.

The *Atlas* discusses the pelagic distributions of the following species (asterisks indicate species whose distributions are covered by both maps and text; the others are described only in the text; the text also includes supplementary information on distributions summarized from the literature):

*Northern Fulmar (*Fulmarus glacialis*); *Greater and *Sooty Shearwaters (*Puffinus gravis* and *P. griseus*); Manx, Audubon's, and Little Shearwaters (*P. puffinus*, *P. lherminieri*, and *P. assimilis*); Cory's Shearwater (*Calonectris diomedea*); *Leach's and Harcourt's Storm-Petrels (*Oceanodroma leucorhoa* and *O. castro*); *Wilson's Storm-Petrel (*Oceanites oceanicus*); British Storm-Petrel (*Hydrobates pelagicus*); *Northern Gannet (*Sula bassana*); Great and Double-crested Cormorants (*Phalacrocorax carbo* and *P. auritus*); Red-necked and Red Phalaropes (*Phalaropus lobatus* and *P. fulicarius*); Pomarine, Parasitic, and Long-tailed Jaegers (*Stercorarius pomarinus*, *S. parasiticus*, and *S. longicaudus*); Great and South Polar Skuas (*Catharacta skua* and *C. maccormicki*); *Herring and Lesser Black-backed Gulls (*Larus argentatus* and *L. fuscus*); Iceland and Kumlien's Gulls (*Larus glaucoides glaucoides* and *L. g. kumlieni*); Thayer's, *Great Black-backed, and Glaucous Gulls (*Larus thayeri*, *L. marinus*, and *L. hyperboreus*); Ring-billed, Black-headed, Bonaparte's, and Laughing Gulls (*Larus delawarensis*, *L. ridibundus*, *L. philadelphia*, and *L. atricilla*); Ivory Gull (*Pagophila eburnea*); Sabine's Gull (*Xema sabini*); Ross' Gull (*Rhodostethia rosea*); *Black-legged Kittiwake (*Rissa tridactyla*); Common, Arctic, Roseate, and Caspian Terns (*Sterna hirundo*, *S. paradisaea*, *S. dougallii*, and *S. caspia*); *Dovekie (*Alle alle*); *Common and *Thick-billed Murres (*Uria aalge* and *U. lomvia*); *Razorbill (*Alca torda*); *Atlantic Puffin (*Fratercula arctica*); and Black Guillemot (*Cepphus grylle*).

As background to these distributions, other sections describe the oceanography of the northwest Atlantic and the eastern Canadian Arctic, and aspects of the conservation and management of eastern Canadian seabirds. The "Vulnerabilities" section summarizes offshore areas where seabirds are potentially most at risk from oil pollution, as illustrated by the combined distributions of Dovekies, murres, Razorbills, and puffins.

Subsequent volumes of this *Atlas* will summarize quantitative seabird distribution data collected on aerial surveys, a technique developed since the publication of the original *Atlas*, and will provide updated information on the sites and sizes of seabird colonies.

1. Introduction

1.1. The Canadian Wildlife Service seabird atlas

The Canadian Wildlife Service (CWS) published its *Atlas of eastern Canadian seabirds* in 1975 (Brown *et al.* 1975*a*). This summarized the data obtained from two distribution surveys, both of which began in the late 1960s. The first, PIROP (Programme integré de recherches sur les oiseaux pélagiques), organized by R.G.B. Brown (CWS) and P. Germain (University of Moncton), provided standardized quantitative information on pelagic seabird distributions, collected from ships at sea in the western North Atlantic, north of 40°N and west of 40°W. The second, organized by D.N. Nettleship (CWS), provided an inventory and census of the major colonies of seabirds in Atlantic Canada and the eastern Canadian Arctic, as part of the CWS program, "Studies on northern seabirds".

The publication of the *Atlas* was timely, because it provided basic information on seabird distributions for use in the environmental assessment required for the boom in offshore hydrocarbon exploration, which began in the mid-1970s. These assessments in turn led to further surveys, partly by CWS but mainly by consultant companies working for the oil industry. As a result of all this work, the data base for pelagic distributions is now four times as large as it was in 1974, the cut-off year for the old *Atlas*. The cut-off date for this revised edition is 31 December 1983.

This new *Atlas* combines the old and new shipboard data, and provides a new set of maps of the pelagic distributions of the commoner seabirds in eastern Canadian waters, along with commentaries and background oceanographic information. It is intended to serve two functions. The first is to give a broad picture of seabird distributions north of 40°N and west of 40°W, according to season. But these maps also serve as a kind of catalogue of the data that CWS has on file. The computer mapping program that generated them can then be used to produce larger-scale maps that show, in greater detail, distributions in a specific area—around an offshore drill-site, for example, or in the path of an oil slick.

Since 1974 a completely new set of seabird distribution data has been collected through aerial surveys. This has not been included here; for technical reasons, it is impracticable to combine shipboard and aerial data in a single map. The latter will be published separately. However, information from aerial surveys has been used here to supplement the shipboard data in some of the commentaries.

1.2. Methods

Pelagic distributions are plotted on two maps, divided at 60°N but with some overlap. The data on the *Atlantic* map refer to 30'N × 1°W blocks but, because of the converging longitudes farther north, the *Arctic* blocks are 1°N × 2°W. As an indication of the scale of the maps, note that each 5°N = 300 nautical miles, or c. 555 km. The months have been grouped into seasons: January–March (winter), April–June (spring/early summer), July–September (summer), and October–December (fall/early winter) in the Atlantic; July–August (late summer) and September–October (early winter) in the Arctic. As in the old *Atlas*, observations were made in 10-min watches in good visibility from a ship moving at not less than 4 knots (7.4 km/h). The data in the old *Atlas* were shown as average numbers per 10-min watch; here we have made an adjustment for the ship's speed, so that the averages now refer to numbers of birds per linear kilometre. This makes it easier to compare our results with those from other quantitative recording systems (e.g. Powers 1982, 1983; Blake *et al.* 1984; Tasker *et al.* 1984). The mapping program will plot these averages as numbers or symbols; the latter have been used here for greater clarity. Underlined symbols indicate averages based on at least 10 watches, but those with asterisks above them on only 1 or 2. The division of the area into blocks has meant that a few data points have been plotted on land. These actually refer to the adjacent coastal waters; points plotted in central Devon Island, for example, refer to observations made in Lancaster Sound. Note that a blank space, without a symbol, indicates an absence of data, not of birds. An alternative, non-quantitative "+/−/o" system has been used for some of the auk maps, and is described in the notes on the species concerned.

This system, like all the others proposed for recording seabirds at sea, has some unavoidable biases (Bailey and Bourne 1972, Powers 1982, Tasker *et al.* 1984). It is to be hoped that the method is sufficiently uniform to reduce variability between observers, but this cannot be eliminated completely. All observers tend to overestimate conspicuous white birds such as fulmars and gulls, and this is compounded by the fact that these species tend to follow ships for long periods, and may therefore be counted during more than one 10-min watch. They are especially attracted to stationary ships, and data from ships moving at less than 4 knots have therefore been rejected. On the other hand,

inconspicuous dark seabirds like the alcids, which do not follow ships, are likely to be underestimated, especially if they are sitting on the water in rough weather. Survey patterns add another bias; large ships rarely venture close inshore, and so there is little or no coverage of the coastal habitat where seabirds are often abundant, as aerial surveys have shown (e.g. McLaren 1982, McLaren and Renaud 1982). The maps combine observations from several years, and the averages may therefore be affected by inter-year differences. This could be avoided by plotting the data for each year separately, but in most cases there are too few observations for this to be practicable.

Tasker *et al.* (1984) review the census techniques that have been used by various pelagic seabird recording schemes. They recommend a standardized method for making quantitative observations, in which the observer counts birds only within a limited range and angle of view—preferably within 300 m of the ship, and within an arc of 90° on one side of the bow. The most recent PIROP surveys (Brown 1984 and unpubl.) have adopted these recommendations. Unfortunately the bulk of our data, collected back in the 1970s, cannot be standardized along these lines. All that we have attempted here is to add a correction for the ship's speed and to express the data in terms of birds/km, instead of birds/10 min watch (see above).

The long-term aim of the standardizations and refinements in technique that Tasker *et al.* (1984) have proposed is to allow the calculation of the *absolute* sizes of seabird populations at sea. I agree that this is desirable, but suspect that it is beyond the capacity of shipboard surveys. Absolute estimates can be made from *aerial* surveys, if these are flown along a pattern of adjacent flight-paths that covers all the marine habitats in the survey area (e.g. McLaren 1982, Renaud *et al.* 1982). On the other hand, most shipboard observations are made in the course of limited transects that cover only a very small fraction of a marine area, and do not even cover all the habitats within it. For example, oceanographic ships rarely work close inshore, a habitat that the aerial surveys have shown to be important to many seabirds. Given these limitations, it is hard to see how one can arrive at any kind of realistic estimates of absolute numbers. I suggest instead that our goal should be the accurate measurement of *relative* variations in the numbers of seabirds, so that the birds' distributions may be compared with, and interpreted in terms of, the occurrence of physical and biological oceanographic phenomena.

The CWS surveys of the numbers and distributions of seabirds breeding in eastern Canada have advanced greatly since 1974, and the results will be published in a separate volume (D.N. Nettleship, in prep.). Some colony maps are given here, to help in the interpretation of pelagic distributions. These are based on data in the old *Atlas*. Note that, for clarity, I have omitted all colonies with less than 100 pairs, and that I have sometimes used a single symbol for several adjacent sites. For further details see Brown *et al.* (1975*a*), Nettleship and Smith (1975), and the references cited in the species accounts.

2. The oceanography of the northwest Atlantic and eastern Canadian Arctic

The oceanographic zonation of the North Atlantic Ocean is determined by two major patterns of circulation (Fig. 1). The *East Greenland Current* is the principal outflow from the Arctic Ocean. It brings cold polar water of low salinity southwest along the whole length of the east coast of Greenland. A lesser outflow of polar water passes through western Baffin Bay and Hudson Strait, and comes down the east coast of Canada, as far south as the northern Gulf of St. Lawrence and southern Newfoundland, as the *Labrador Current*. The dominant feature farther south, between c. 15°N and 45°N, is a clockwise gyre of warm water that circulates around the Sargasso Sea. The *Gulf Stream*, the western edge of this gyre, brings warm, highly saline water up the east coast of North America, past the southern Grand Banks, and continues northeast towards Europe as the *North Atlantic Current*. A northerly branch mixes with the *East Greenland Current* and passes up the west coast of Greenland, north to c. 70°N, as the *West Greenland Current* (Sverdrup *et al.* 1942; Dunbar 1951; Anon. 1958, 1968; Hachey 1961; Collin and Dunbar 1964; Cushing 1971; Norderhaug *et al.* 1977).

These circulation patterns determine the extent of ice cover (Fig. 2), which in turn has a strong influence on the distributions of marine organisms, includ-

Figure 1

The principal current systems in the northwest Atlantic and the eastern Canadian Arctic (after Hachey 1961). Key: 1, *Baffin Land Current*; 2, *West Greenland Current*; 3, *Labrador Current*; 4, *North Atlantic Current*; 5, *Gulf Stream*; 6, *East Greenland Current*

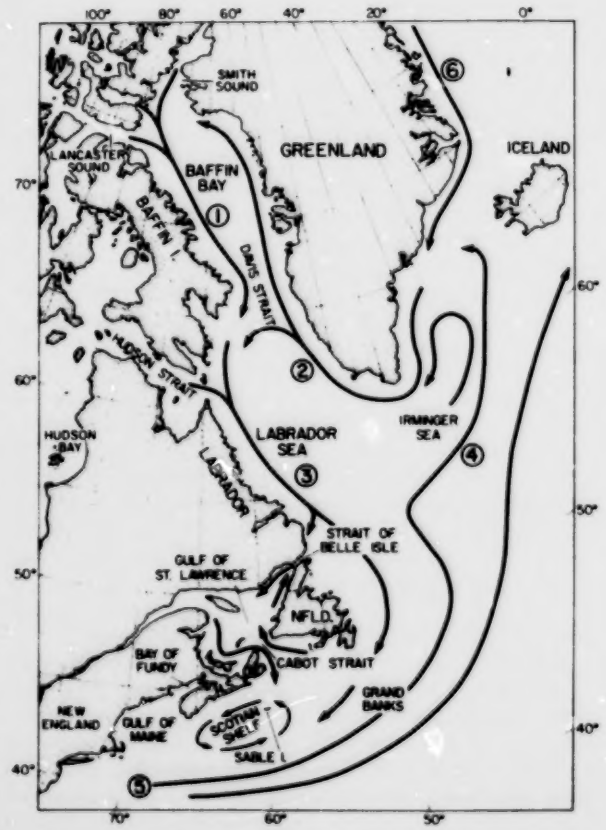
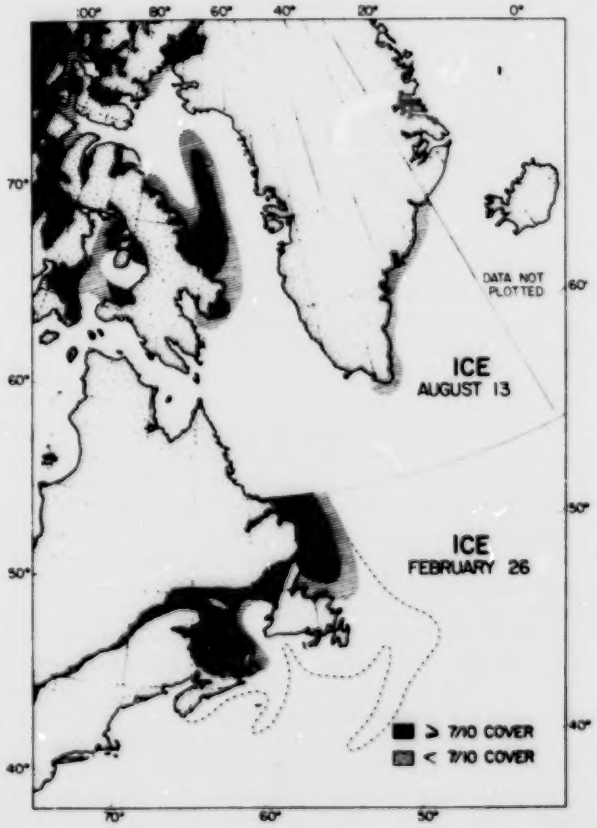


Figure 2

Minimum and maximum pack-ice cover. The maps show the average southern extent of pack-ice on 13 August (minimum) and 26 February (maximum), and the southern limits of drift-ice in April–May. From Brown *et al.* (1975), based on the 1969–73 *Ice summary analyses* published by Canada Department of Transport, Meteorological Branch, Toronto, supplemented by Anon. (1958) and Hachey (1961).



ing seabirds. The waters influenced by the warm *North Atlantic Current* remain free of ice all year round, as far north as 69°N along the west coast of Greenland. On the other hand, the Arctic Ocean outflows ensure that the east coast of Greenland, western Baffin Bay, and the channels between the Canadian Arctic Islands remain ice-bound for all or part of the summer. In early spring the *Labrador Current* brings pack-ice south to eastern Newfoundland and, occasionally, as far as the southern Grand Banks. It also brings icebergs to eastern Newfoundland waters, most of them calved from the glaciers that run off the Greenland Ice-cap into Baffin Bay. Most of the Gulf of St. Lawrence freezes over in winter and when the ice breaks up in spring the St. Lawrence outflow carries it as far south as eastern Nova Scotia. Paradoxically, the extreme north of Baffin Bay remains free of ice all winter—the "North Water" polynya. The sea freezes there, but persistent northerly winds carry the ice south as fast as it forms; an ice-jam across the narrows of Smith Sound prevents ice from farther north from drifting down to replace it.

Physical oceanographers define water masses in terms of their temperature–salinity (T–S) relationships (e.g. Pickard 1971, 1975). Salomonsen (1965, 1972), Dunbar (1968), and Ashmole (1971) have combined T–S data with information on the distributions of marine invertebrates to divide the *Atlas* survey area into four marine zones (Fig. 3):

(1) High Arctic (Dunbar's "arctic")—unmixed polar water in which the surface layers are close to freezing (0–3°C) even in August, the warmest month, and the salinities usually <31‰; pack-ice persists for all or much of the year.

(2) Low Arctic (Dunbar's "subarctic")—a mixture of polar with warmer waters in which August surface temperatures are 4–10°C, and salinities 31–34‰; pack-ice is present for a relatively limited winter season.

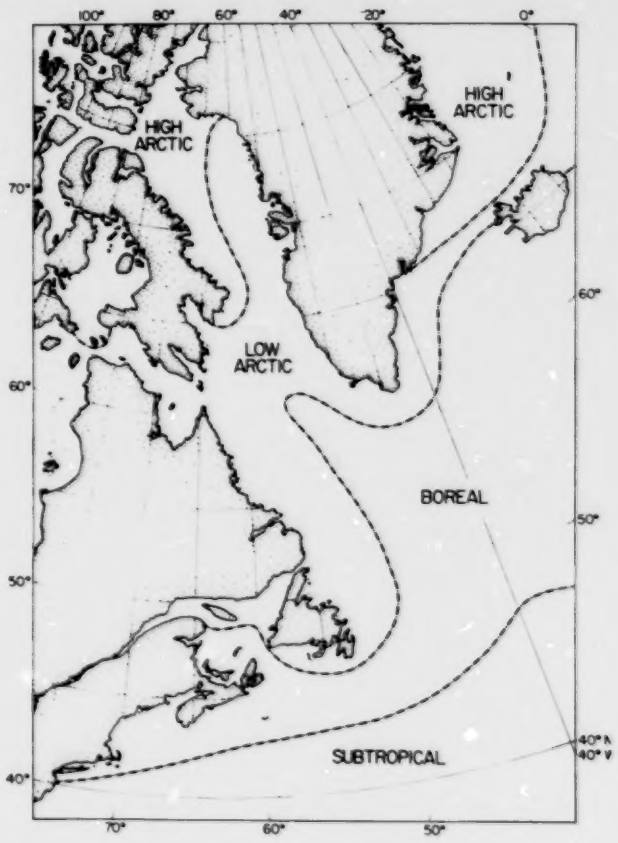
(3) Boreal—the northwest edge of the *Gulf Stream/North Atlantic Current* where August surface temperatures range between 10 and 19°C, but salinities, between 31 and 35‰, overlap with those in the Low Arctic; the sea usually does not freeze in winter, except in enclosed bays and gulfs.

(4) Cool subtropical (Ashmole's "subtropical")—the waters of the northwest Sargasso Sea, immediately southeast of the *Gulf Stream/North Atlantic Current*, where August surface temperatures range between 19 and 23°C, with salinities of >35‰.

These are only approximations. The southern Gulf of St. Lawrence, for example, is ice-bound in winter but warm in summer, and may be classed either as Low Arctic or Boreal (Dunbar 1968). However, the important point is that these marine habitats have specific communities of fish, plankton, and other organisms associated with them (e.g. Bary 1963). Seabirds are also often associated with these communities and habitats (Brown *et al.* 1975*b*; Pocklington 1979; Brown 1979, 1980*a*; Shuntov *et al.* 1981). For example, Dovekies (*Alle alle*) are confined to High Arctic waters in Baffin Bay in summer, and are commonest in winter in areas influenced by the *Labrador Current* (see section 5.15). The ranges of Cory's Shearwater (*Calonectris diomedea*) and the Greater Shearwater (*Puffinus gravis*) off Atlantic Canada in summer overlap very little

Figure 3

Oceanographic zonation in the northwest Atlantic and eastern Canadian Arctic. From Brown *et al.* (1975), based on Ashmole (1971), Dunbar (1968), and Salomonsen (1965, 1972). (Note that Dunbar (1968) differs in putting Hudson Bay in the High Arctic, and the whole of the Gulf of St. Lawrence in the Low Arctic.)



(Brown 1977; see also sections 5.2, 5.3). These very similar species occur respectively in areas influenced by the *Gulf Stream*, and in the cooler waters farther north.

In many cases seabirds are not distributed at random over a preferred marine habitat. They tend to be concentrated in areas where the water column is unstable: at oceanographic fronts, for example, over the edges of continental shelves, and in other anomalous areas (Brown 1980*a*). In fall and winter Red Phalaropes (*Phalaropus fulicarius*) are largely confined to restricted zones such as the tide-rips in the Bay of Fundy, or to such larger-scale anomalies as the fronts at the outer edges of the *Labrador Current* and the Senegal and California upwellings (Brown 1979, 1980*a*: Fig. 8; Orr *et al.* 1982; Briggs *et al.* 1984). On Georges Bank, off New England, Wilson's Storm-Petrels (*Oceanites oceanicus*) are commonest over the shelf-break (Powers 1983). Wintering Dovekies are also common over the edges of the Scotian Shelf and the Grand Banks (Brown 1980*b*; Bradstreet and Brown 1985, see also Maps 11b–f). In several cases zooplankton were present in high local concentrations in these anomalies; in others, comparisons with similar anomalies

elsewhere (e.g. Pingree *et al.* 1974, Ainley and Jacobs 1981, Schneider 1982) suggested that such concentrations were to be expected.

Farther north many seabirds are attracted to glacier faces, where the ablation of melt-water induces a local upwelling in which zooplankton may be brought to the surface (Hartley and Fisher 1936, Dunbar 1951, McLaren and Renaud 1982, Renaud and McLaren 1982). Large numbers of seabirds occur in spring at or near the edge of the pack-ice in northern Baffin Bay (McLaren 1982, Renaud *et al.* 1982), evidently attracted by the large numbers of polar cod (*Boreogadus saida*) and epontic crustaceans associated with this habitat (Dunbar 1981; Bradstreet 1982*a*, *b*; Bradstreet and Cross 1982; Cross 1982). It is probable that the birds increase their foraging efficiency substantially when they feed on local concentrations of prey such as these. This has been demonstrated, in terms of energetic expenditure, for foraging baleen whales (Brodie *et al.* 1978), but such calculations have not yet been attempted for seabirds.

3. Conservation and management

Seabird populations are affected by human activities, often adversely, and the evidence suggests that these pressures have become especially strong within the last few decades. The object of this chapter is to describe some of these effects and, where possible, to suggest ways of alleviating them.

3.1. Predation

3.1.1. Hunting

Seabirds, waterfowl, shorebirds, and other birds have always been hunted for food by the native peoples of eastern North America. The European settlers continued this practice as they gradually colonized the continent from the 17th century onwards, and they greatly expanded the scale of the hunt. Their firearms allowed them to harvest game efficiently and intensively, and the need to provide food for the growing new cities—"market" hunting—gave them every incentive to do so. Birds of various species were also killed for their feathers, as fish-bait, and as pests, and the destruction of breeding habitats, coastal and inland, reduced many populations still further.

For one or more of these reasons, three of the nine North American colonies of the Northern Gannet (*Sula bassana*) were exterminated in the course of the 19th century, and what may once have been the largest colony in the world, on Bird Rocks, Magdalen Islands (47°50′N, 61°09′W), in the Gulf of St. Lawrence has been reduced from c. 75 000 pairs to a mere 5300 today (Fisher and Lockley 1954, Nettleship 1976, Cramp and Simmons 1977). Egg-collecting and feather-hunting virtually wiped out the gull and tern colonies of New England by 1900 (Drury 1973–74). The flightless Great Auk (*Pinguinus impennis*), the "penguin" of the North Atlantic, had disappeared from its last stronghold, Funk Island, Nfld. by 1800, after some 250 years of attrition by hungry fishermen, culminating in a short and intensive slaughter of the birds for their feathers (Grieve 1885, Fisher and Lockley 1954, Murray 1968). The last Great Auks of all were killed in Iceland in 1844—collected for scientific purposes, ironically enough; their very rarity gave them value as museum specimens, and they died just too soon to be saved by the growing ornithological trend towards the conservation and study of living birds (Newton 1861).

Irresponsible collectors are still with us, unfortunately. The eggs and nest of a Ross' Gull (*Rhodostethia rosea*) at the only known colony in the Canadian Low Arctic were illegally collected as recently as 1981 (Neil 1981).

However, the tide had turned by the early 1900s, when the United States enacted legislation that gave complete protection to all birds, apart from "pest" and "game" species, prohibited market hunting, and restricted "sport" hunting to a limited season in the fall and winter to protect the breeding stocks. Then, in 1916, the USA and Great Britain, on behalf of Canada, signed the Migratory Birds Convention which, as the Migratory Birds Convention Act of 1917, enshrined these measures in Canadian law. The Act was extended to Newfoundland when that country became a province of Canada in 1949. It covers all the seabirds described in this *Atlas* except for cormorants (*Phalacrocorax* spp.) which, with other supposedly "non-migratory" and pest species, were omitted by the Act and so, by default, come under provincial jurisdiction. Subsistence hunting by aboriginal peoples is still permitted. Otherwise the only seabirds that may legally be hunted in Canada today are murres in Newfoundland during the winter, also for subsistence purposes. The annual Newfoundland murre kill is of the order of 250 000–500 000 birds, at least 75% of them Thick-billed Murres (*Uria lomvia*) from the eastern Canadian Arctic and west Greenland (Gaston 1980, Gaston *et al.* 1983, Wendt and Cooch 1984). Unfortunately the regulations are difficult to enforce in the remoter areas of Atlantic Canada, and a great deal of illegal hunting undoubtedly continues (e.g. Gaston *et al.* 1983).

In Greenland subsistence hunting is an important source of food for the whole community. Thick-billed Murres and Common Eiders (*Somateria mollissima*) are the principal birds hunted. The other auks, along with gulls and fulmars, are also taken regularly (Salomonsen 1967). Salomonsen put the annual murre kill at 750 000 birds, but a re-analysis by Kampp (1982) suggested a more realistic total of c. 193 000 birds, at least 10% of which were migrants from Canadian colonies. The majority, c. 98 000, were from Upernavik District, west Greenland (c. 73°N), and the harvest there was a market hunt; large numbers of murres (52 885 in the peak year of 1968) were frozen and shipped down to southern Greenland (Salomonsen 1967, Kampp 1982). Many of these were breeding adults shot at or close to the colonies—a procedure that inevitably also resulted in a massive additional mortality of murre chicks on the cliffs. Both market hunting and the killing of seabirds at their colonies are now illegal in Greenland (Salomonsen 1979*a*) though, as in Canada, the legislation may prove difficult to enforce.

Some rough estimates of the Upernavik murre population in 1974 suggested that it was smaller than

in the 1930s (Evans and Waterston 1976). Excessive hunting cannot have been the only reason: the mass drownings of murres in salmon nets have undoubtedly played a part (see section 3.2). However, hunting, even if carefully regulated, is a serious potential hazard to populations of murres and of most other seabirds. Waterfowl and upland game birds, the usual targets of bird-hunters in North America and Europe, have a rapid reproductive turnover, combining the annual production of many young with a short adolescent period and a high "natural" annual adult mortality (e.g. Perrins and Birkhead 1983). Their populations can therefore cope fairly easily with the additional "unnatural" mortality imposed by hunting; many of the harvested birds are in any case juveniles, with a higher natural mortality than adults, and thus likely to die before they can reproduce. Murres have a very different reproductive strategy. They lay only one egg a year, do not begin to breed until they are c. 5 years old, and have a very low natural adult mortality rate (e.g. Tuck 1961, Gaston and Nettleship 1981, Kampp 1982). This makes it difficult for their populations to absorb and recover from the high additional unnatural mortalities that both hunting and net-drowning are clearly imposing on them. Given this, the scale of hunting both in Greenland and Newfoundland seems excessive. Unfortunately, for economic and political reasons, it will prove very difficult to stop or even limit the murre hunt in either jurisdiction.

3.1.2. Other predators

Seabirds have few predators while they are at sea, and most species avoid predation on land by breeding on inaccessible offshore islands. The fate of the Great Auk shows what happens when a land-predator—in this case man—reaches a seabird colony. The intrusion of polar bears (*Ursus maritimus*) and arctic foxes (*Alopex lagopus*) may have equally drastic effects (e.g. Marshall 1952, Macdonald 1979, Quinlan and Lehnhausen 1982). In some cases the predator has been deliberately or accidentally introduced by man, as with foxes in the Aleutians, and brown rats (*Rattus norvegicus*) in the Faeroes (Joensen 1966, Jones and Byrd 1979).

Island nesting does not insulate the birds from avian predators, but they have evolved protective behaviour, such as nesting on steep cliffs or underground, or visiting their colonies only at night, which minimizes these risks. Unfortunately Herring and Great Black-backed Gulls (*Larus argentatus* and *L. marinus*), the principal avian predators at seabird colonies in Atlantic Canada, have greatly increased during the last 75 years (Drury 1973–74), at first because of protection (see above), but latterly because the supply of edible human garbage reduces the mortality rate of the birds in winter. This in turn has led to greater predation of other seabirds in summer. The population of terns (*Sterna* spp.) in New England has declined drastically since 1930 (Drury 1973–74), and that on Sable Island, NS, has been virtually wiped out (Lock 1973). Herring Gulls in Newfoundland take the chicks of Atlantic Puffins (*Fratercula arctica*) and klepto-parasitize the food brought back to the colony by their parents; there is an inverse correlation between the intensity of these activities and the breeding success of the puffins (Nettleship 1972). Attempts to control gull populations by destroying the birds or their eggs have had only partial success (e.g. Drury and Nisbet 1969, Gramlich 1975, Duncan 1978). The most effective solution to the problem, though it is slow to produce results, is to dispose of garbage in such a way that it is inaccessible to the birds.

3.2. Seabirds and the fishing industry

3.2.1. Mortality in fishing gear

In the mid-1960s an important pelagic fishing ground for Atlantic salmon (*Salmo salar*) was discovered off the west coast of Greenland. This was quickly exploited by Faeroese and other non-Greenlandic fishermen, fishing offshore with monofilament gill-nets set close to the surface. It soon became apparent that these were not only catching very large numbers of salmon, but drowning large numbers of murres as well (Tull *et al.* 1972, Christensen and Lear 1977, Kampp 1982). Christensen and Lear estimated an annual toll of the order of 200 000 murres in the early 1970s, along with 10 000 Dovekies, 2000 Black Guillemots (*Cepphus grylle*) and Greater Shearwaters, and smaller numbers of other species. The impact of this fishery on the salmon stocks was so severe that it has been restricted since 1976 to Greenlanders fishing close inshore, and presumably this change has also reduced the toll of murres (Salomonsen 1979*a*). However, Piatt and Reddin (1984) point out that the Greenlanders themselves are now using monofilament gill-nets, and the fact that they are setting them inshore, close to the murre colonies, has probably led to a renewal of the murre mortality. It would be useful to assess this by repeating the net-drowning investigations of the early 1970s.

Monofilament gill-nets are used increasingly in Newfoundland waters as well, set at the surface for salmon, and on the bottom for Atlantic cod (*Gadus morhua*). Piatt *et al.* (1984) reported a significant mortality of Common Murres (*Uria aalge*) and Atlantic Puffins in nets off the large colonies in eastern Newfoundland, and to some extent out on the Grand Banks. Preliminary assessments of the annual toll suggest a peak figure of the order of 30 000 murres in the Witless Bay area in the early 1970s, or 18–20% of the adult breeding population. However, the kill declined to 3–4% in the early 1980s because of a reduction in the fishery due to a decline in capelin (*Mallotus villosus*), the principal prey of both cod and murres. Piatt *et al.* (1984) point out that annual adult murre mortality from *all* sources, natural and unnatural, must not exceed c. 6–12% if the population is to remain stable. Net-drowning may therefore have a significant effect on the populations even at this reduced level.

Brun (1979) estimated that thousands of murres, puffins, fulmars, gannets, and Black-legged Kittiwakes (*Rissa tridactyla*) were caught on baited long-line hooks set off northern Norway in 1969. It is not known whether seabirds are caught on hooks in Canadian waters, but long-lining is relatively unimportant in the northwest Atlantic fisheries (ICNAF/NAFO 1952–83), and any such toll is probably small.

Seabird mortality in fishing-gear is not confined to the *Atlas* survey area. Apart from the long-line mor-

talities, Brun (1979) also estimated a toll of at least 40 000 birds—mainly auks, cormorants, and diving ducks—drowned in 1969 in nets set off Runde, southwest Norway. At least 100 000 seabirds a year are taken in gill-nets in the North Pacific (King *et al.* 1979). It is a difficult problem, because both seabirds and cod are attracted to areas where their common prey, capelin and other small fish, are also abundant. By the same token, these are also the most profitable areas in which to set fishing gear. One solution would be to prohibit the use of gill-nets close to seabird colonies during the breeding season, but this would probably be economically unacceptable to the inshore fishermen.

3.2.2. Competition for a common resource

The cases discussed in the last section are all of *indirect* conflicts between seabirds and fishermen. The targets of the fishermen are large predatory species, and the birds feeding in the same area are accidentally caught in the fishing gear. It would be technically possible to use monofilament gill-nets to fish for murres *directly*, but fortunately this has not yet been attempted. However, recent developments in the fishing industry pose a threat of another kind (ICNAF/NAFO 1952–83). There is an increasing trend away from the traditional fishery for cod and other large species towards the smaller fish and crustaceans that are the common prey of all the higher predators—large fish and marine mammals as well as seabirds. The predators and the fishermen, in other words, are in direct competition for a large but finite food resource, and the efficiency of modern fishing techniques leaves little doubt about who will win. The recent scarcities of such important prey as the anchoveta (*Engraulis ringens*) off Peru and the pilchard (*Sardinops ocellata*) off South Africa are partly the result of over-fishing, and the local seabird populations have been adversely affected in both cases (Crawford and Shelton 1978, Valdivia 1978, Továr and Fuentes 1980).

The prime example of a potential conflict in the *Atlas* survey area is with the fishery for capelin, a fish traditionally taken by man in small numbers along the coasts of Newfoundland and Greenland for food, fertilizer, and bait. A commercial offshore fishery began in the northeast Atlantic in the 1950s and was extended to the offshore spawning grounds on the southern Grand Banks in 1970—to such effect that it had to be closed in 1978 to allow stock recruitment. Meanwhile the fishery for non-breeding capelin off northeast Newfoundland continues, and a roe fishery for the stock that spawns along the southeast coast of Newfoundland began in 1979 (Templeman 1948, Jangaard 1974, Winters and Carscadden 1978, Anon. 1982, Rowe and Collins 1982, Brown and Nettleship 1984, Carscadden 1984).

At its peak, the Grand Banks fishery was taking over 300 000 t of capelin a year (ICNAF/NAFO 1952–83)—a harvest of the same order as that taken by seabirds (c. 250 000 t), and by whales and seals (c. 300 000 t each), but less than that taken by the larger fish (Winters and Carscadden 1978, Brown and Nettleship 1984). The question of competition obviously arises. The catch limits for the capelin fishery are set with the requirements of the other predators in mind, but the development of the fishery has run ahead of our understanding of the population dynamics and even the biomass of the Newfoundland capelin stocks, so that there is room for miscalculation in these management assessments.

The consequences to seabirds could be serious. Brown and Nettleship (1984) note that capelin are central to the diets of the murres, puffins, and other seabirds that breed in the important colonies in southeast Newfoundland and, for the auks at least, no suitable alternative prey is available to them there. In the summer of 1981, for undetermined reasons, the puffins breeding in Witless Bay were unable to find capelin, and instead brought cod to their young. Few of the chicks survived (Brown and Nettleship 1984). Prey scarcities of this kind are known to occur from time to time, and seabirds can adjust to them to some extent (e.g. Murphy 1936; Harris and Hislop 1978; Vermeer 1978, 1980). However, they would probably find it difficult to adjust to a permanent scarcity of prey brought about by the fishing industry.

3.3. Chemical pollution

3.3.1. Oil

The vulnerability of seabirds to oil spills is well known (e.g. Bourne 1976, Gunkel and Gassmann 1980, Brown 1982). Oil kills seabirds directly by destroying the waterproofing and insulating qualities of their feathers. Oil ingested in small quantities may also have sublethal effects on the birds' reproductive and excretory physiology. Oil spills are most hazardous in cool waters because the oil remains liquid and therefore more contaminating; at warmer temperatures the lighter fractions quickly evaporate and leave behind a relatively innocuous residue of tar-balls (e.g. Levy and Walton 1976).

Several incidents in the *Atlas* survey area have demonstrated these effects. The three largest spills came from wrecked oil tankers: *Arrow* in Chedabucto Bay, NS, February–March 1970 (Brown *et al.* 1973); *Argo Merchant* on Nantucket Shoals, Mass., December 1976 – January 1977 (Powers and Rumage 1978); and *Kurdistan* in Cabot Strait, March–May 1979 (Brown and Johnson 1980). Smaller spills have also taken their toll, for example the small leak from the oil-barge *Irving Whale* off southern Newfoundland, February–March 1970 (Brown *et al.* 1973), and the chronic pollution along the southeast coast of Newfoundland described by Tuck (1961). The principal victims in these incidents have been auks (mainly Thick-billed Murres and Dovekies) and, in coastal regions, diving ducks, grebes (*Podiceps* spp.), and Black Guillemots. The *minimum* mortality in each case was in the thousands, though it is probable that the *true* mortality was greater than the field reports suggest. Oiled birds are usually seen only when they drift ashore. The prevailing winds in Atlantic Canadian waters tend to make oil slicks drift off to the east, and many spills never come to land at all (e.g. Brown 1973*a*, Brown *et al.* 1973).

In the last 15 years, exploration for hydrocarbons has taken place over virtually all of the eastern Canadian offshore zone, from Lancaster Sound to the Scotian Shelf, and off west Greenland (see the journal *Oilweek*, Calgary). Test wells have demonstrated significant fields of natural gas off central Labrador and

Sable Island, and a large reservoir of oil at the Hibernia well-site on the northeast Grand Banks. So far, the only significant accidental leak from an offshore rig was the blow-out of gas at the Vinland site, near Sable Island, in February–March 1984; a small number of murres appear to have been oiled by the condensate from this (A.R. Lock, pers. commun.). However, the hazards will greatly increase when these fields reach the production stage. The Hibernia field lies across the main path of drifting icebergs in the North Atlantic (e.g. Hachey 1961), and these will not only place the production structures at risk, but also preclude the laying of pipelines to the coast. The oil will have to be pumped directly into tankers, and accidental spillage, especially in bad weather, seems inevitable.

The principal hydrocarbon discoveries farther north are the reservoirs of oil and natural gas in the western Canadian Arctic and the Alaskan North Slope. It has been suggested that the gas be liquefied and brought out by icebreaker-tankers through Lancaster Sound and Baffin Bay (Arctic Pilot Project 1980). The immediate hazards of such an operation are an accidental explosion of the cargo and the release of bunker fuel should the ship be holed by ice. However, the chance of a major pollution incident will increase immeasurably if *oil* is also brought south by this route. The possible long-term effect on the marine environment of the disruption of pack-ice cover by an all-year operation of this kind is also a matter of concern.

3.3.2. Other chemicals

The toxicity of pesticides and their residues, and of PCBs and heavy metals in the marine environment, has been the subject of much research during the last two decades. These chemicals are taken up from the water column by animals at the lower trophic levels in the food web, and accumulate in the bodies of the higher predators. Bourne (1976) reviewed their effects on birds. Their action is usually indirect: for example, they affect the physiology of eggshell deposition and thus the hatchability of the egg, rather than killing the bird. This has been enough to cause drastic declines in the populations of some fish-eating seabirds, most notably in Brown Pelicans (*Pelecanus occidentalis*) in California and the Gulf of Mexico (e.g. Bourne 1976, Keith 1983). The most serious case in the *Atlas* survey area was the virtual elimination of the Osprey (*Pandion haliaetus*), a secondary seabird, from the northeast United States (e.g. Poole and Spitzer 1983). A recent decline in the gannet population of Bonaventure Island, in the Gulf of St. Lawrence, was at least partly due to infertility induced by pesticide residues (Nettleship 1975).

The obvious solution is to treat our industrial wastes more carefully—both the Osprey and Brown Pelican populations are now recovering. Unfortunately, the sophistication of our industrial technology is such that wastes that were not considered toxic a decade ago, and perhaps did not even exist then, have suddenly become a problem today. Constant monitoring is the only remedy.

4. Vulnerabilities (Maps 1a–h)

It will be clear from the species accounts in section 5 that the waters off Atlantic Canada and the eastern Canadian Arctic support very large populations of seabirds. Our breeding populations are augmented, at one season or another, by large numbers of non-breeding migrants, some of which come from as far away as northern Russia and Antarctica. It is important to remember that an environmental mishap in our waters could affect the seabirds of the whole Atlantic Ocean.

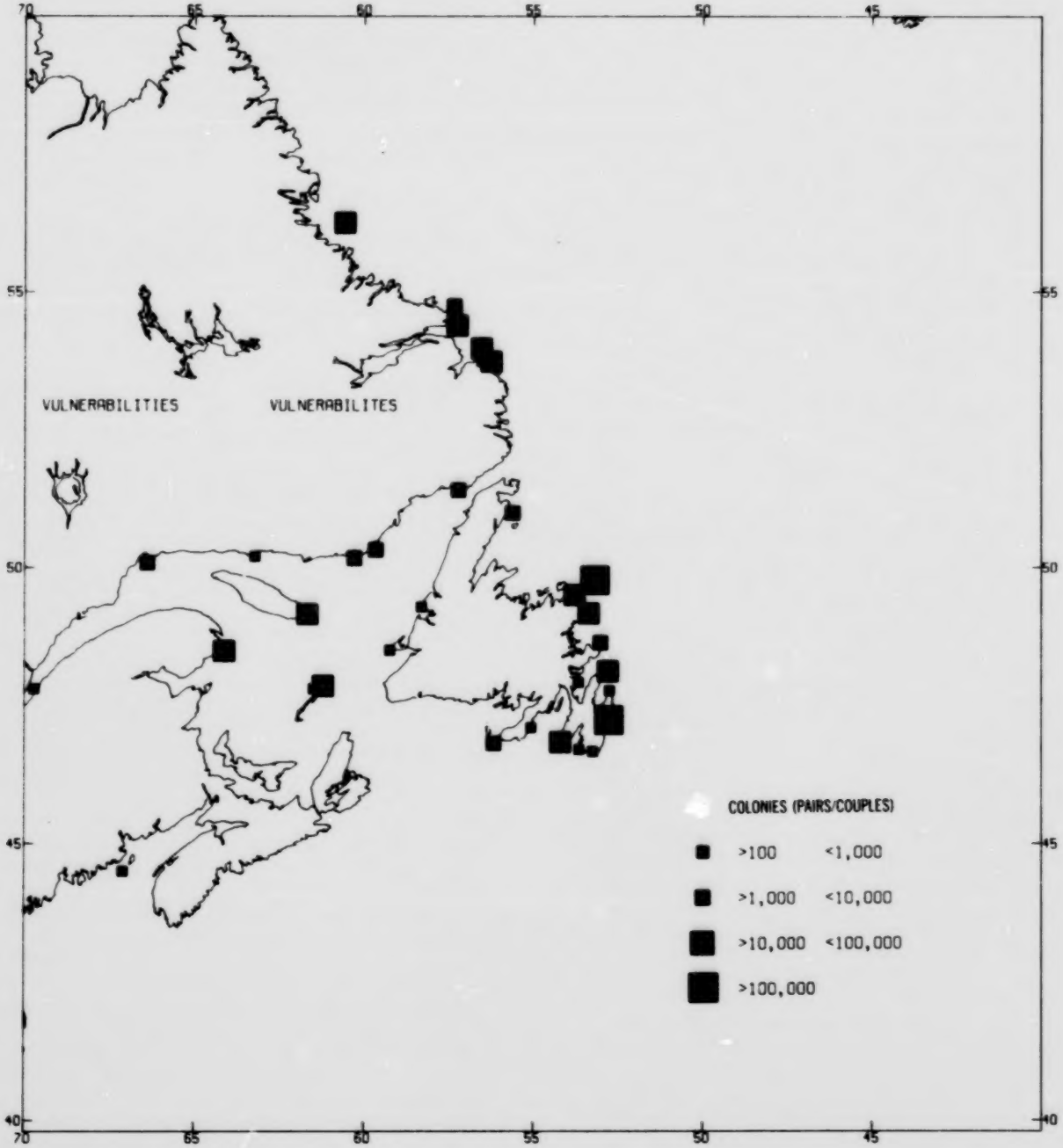
One of the principal functions of this *Atlas* is to provide basic information about seabird distributions in our waters that may be used in assessments of environmental risks. In doing so, it is important to bear in mind the limitations of the data. The averages on the species maps are based on relatively few observations in most cases. The maps are forecasts only in a very general sense: a "0" average is certainly not a guarantee of zero risk for the species and area in question. It might be best to think of them as actuarial assessments of the probability that the species will be present. It is also important to remember that blank areas on the maps indicate an absence of *records* and not necessarily of birds. This is especially true of inshore areas, where we have very few observations. One of the most serious gaps in this *Atlas* is the almost total lack of information about waterfowl and of seabirds close inshore (apart from the sites of their colonies). This will be partly remedied when the aerial data are published.

The seabird species at risk in any given situation will obviously depend on the location and nature of the hazard. An assessment of the effects of an oil spill will require information about auks offshore and seaducks inshore, for example, while one on pesticide residues would have to take gannets and other large fish-eating seabirds into account. We cannot draw up a single series of maps that can be used for every possible contingency. However, most environmental assessments dealing with eastern Canadian waters are concerned with the hazards presented by the offshore oil industry, and so these "Vulnerability" maps are presented for quick reference. They show the combined distributions of the five species of auks regularly occurring offshore—Dovekie, Razorbill, Atlantic Puffin, and the two murres—along with their principal colonies. This only gives a general picture. Details of other species potentially at risk from oil spills have to be added, depending on the area and season: for example, the large flocks of shearwaters on the southern Grand Banks in June or in the Bay of Fundy in August (see maps).

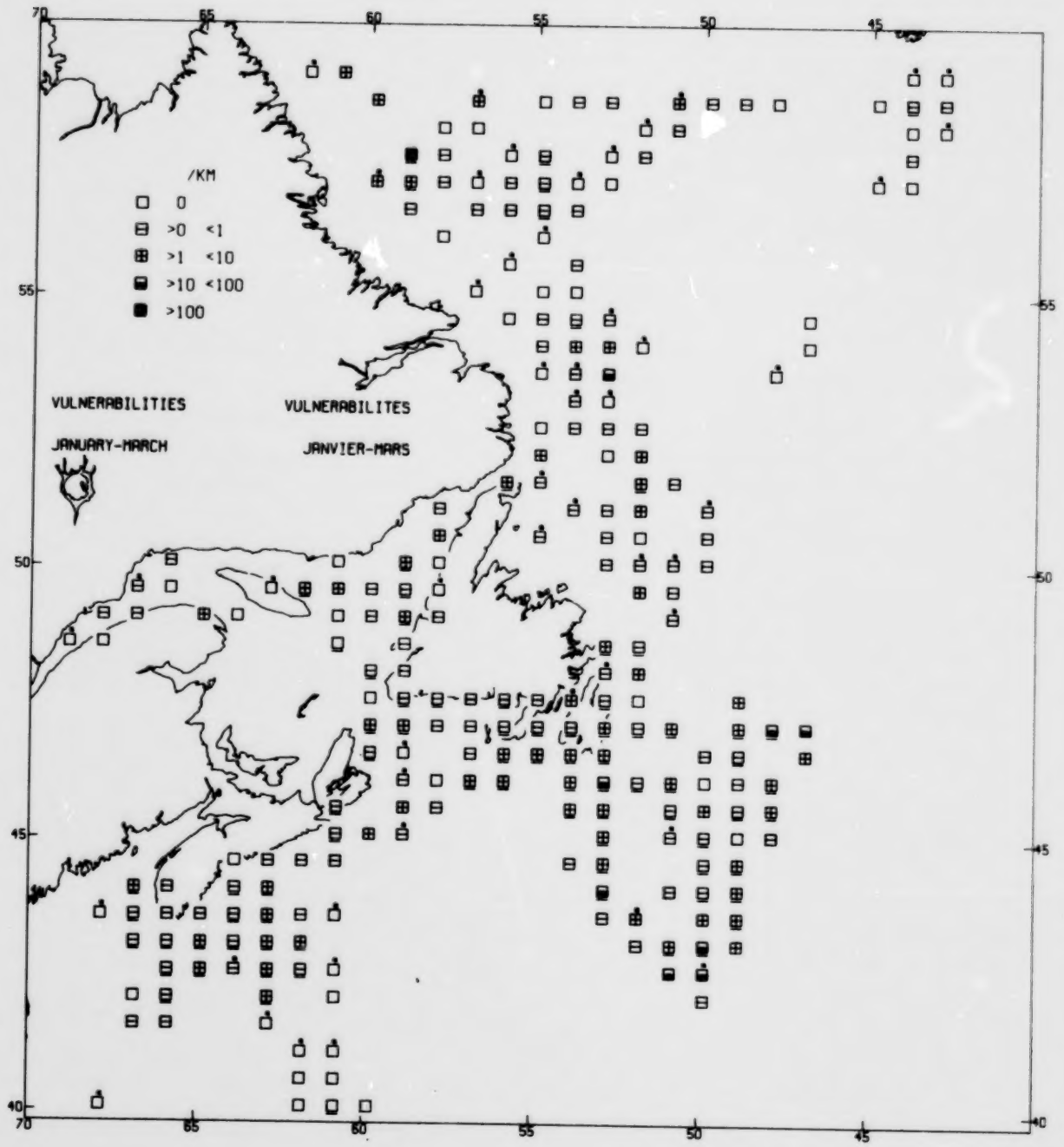
Maps 1a–h

The distributions of five auk species regularly occurring offshore—Atlantic Puffin, Dovekie, Common and Thick-billed Murres, and Razorbill—indicating where and when they are most vulnerable to oil spills

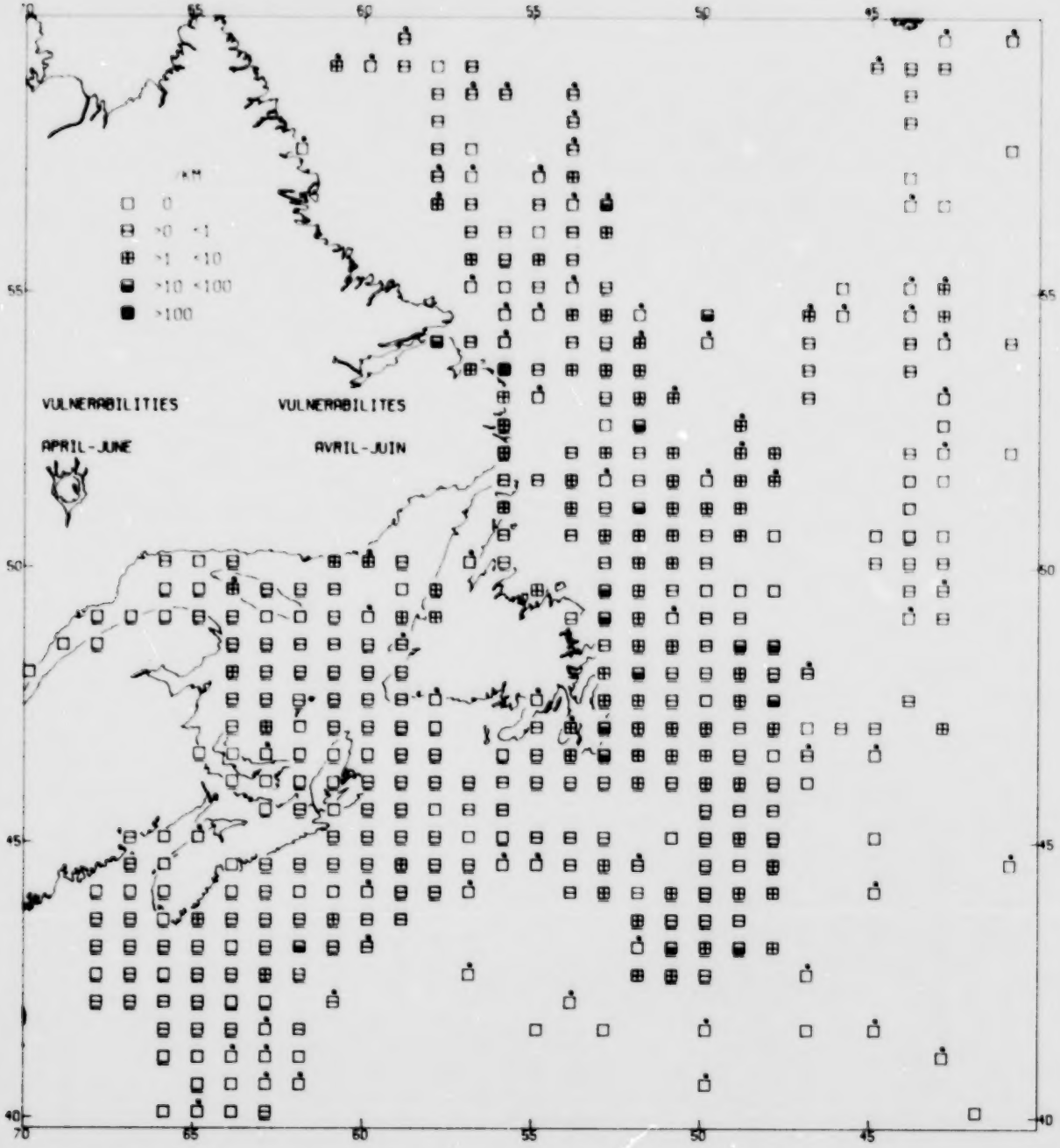
Map 1a
Atlantic colonies



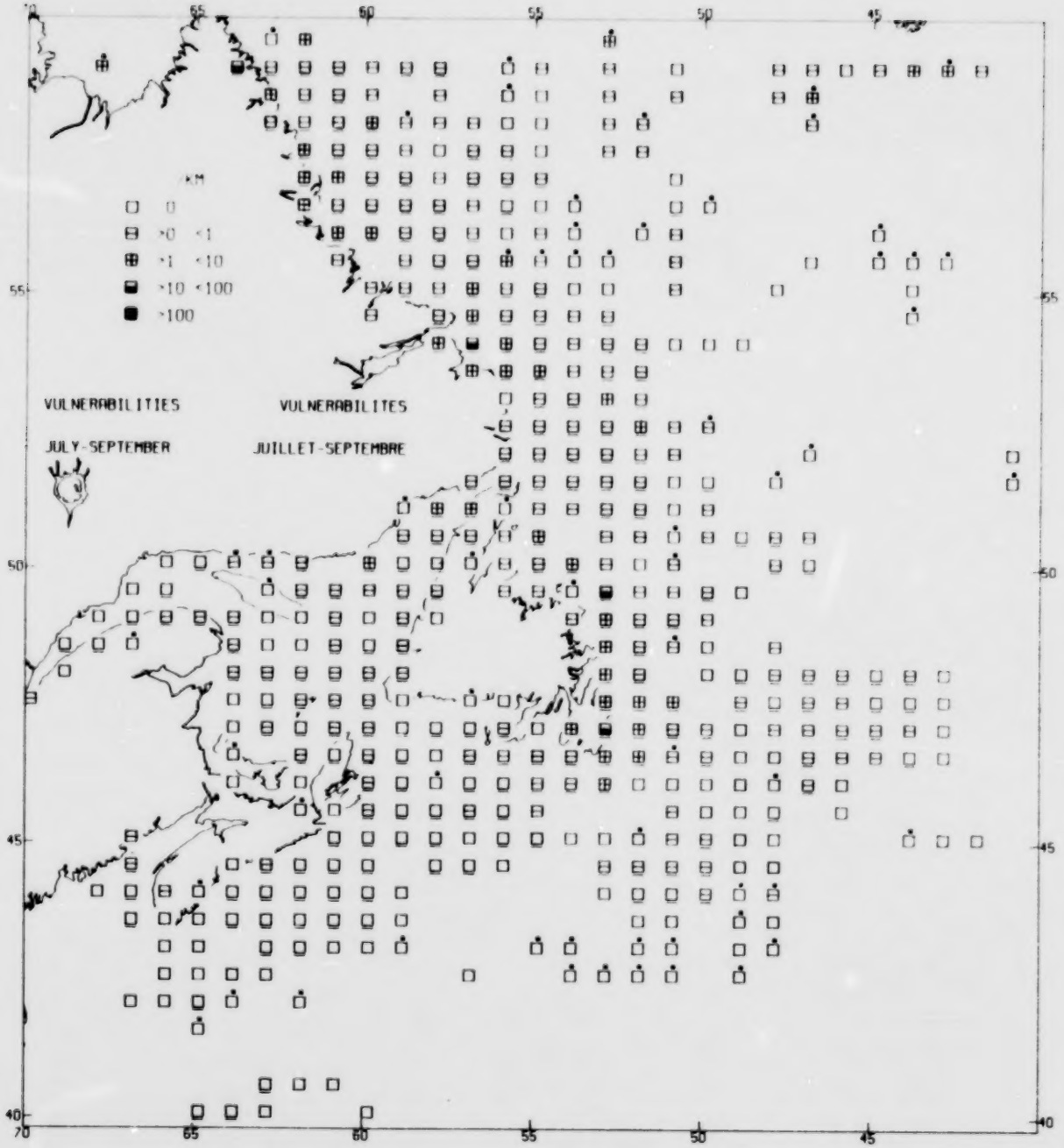
Map 1b
Atlantic, January–March



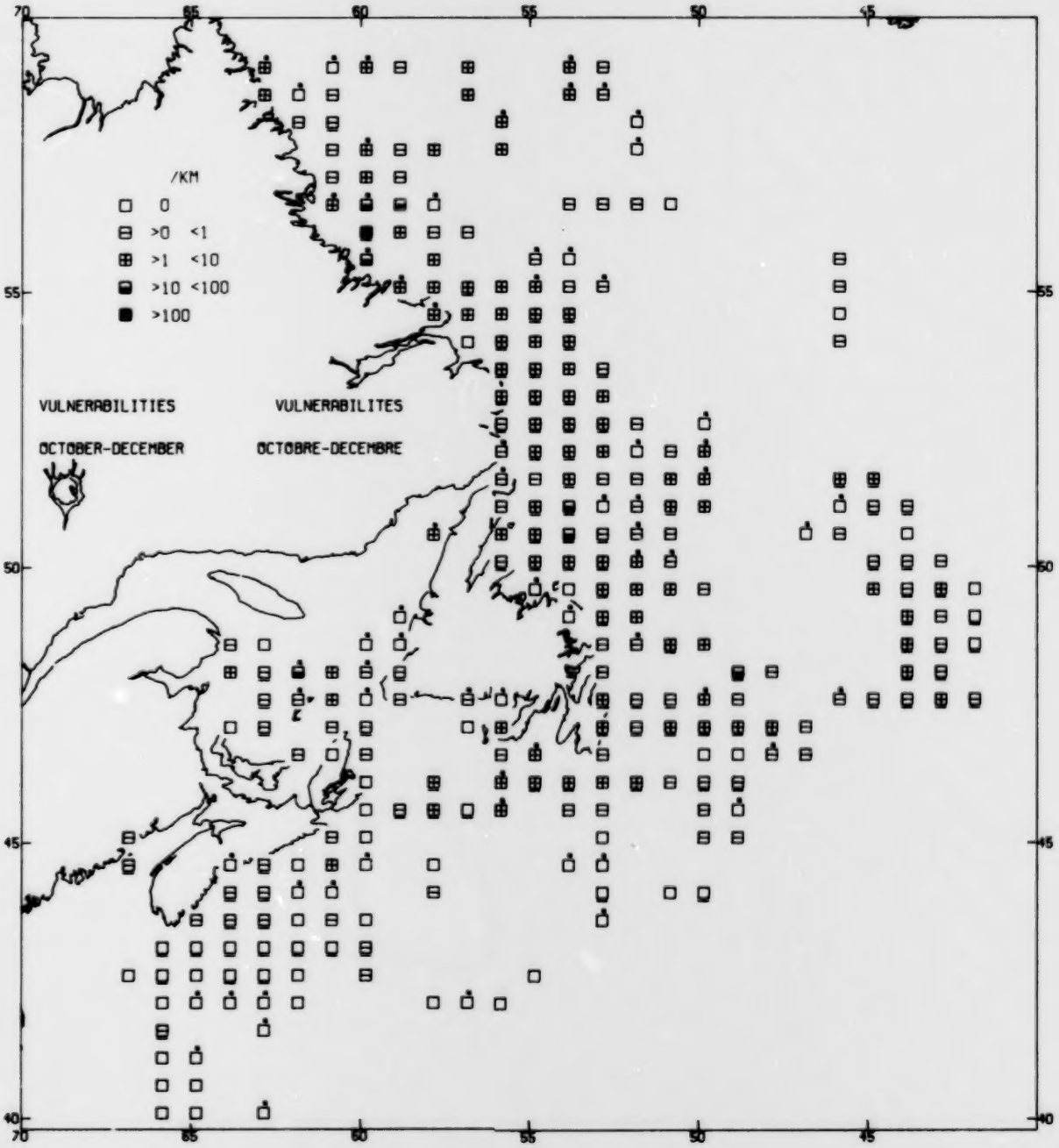
Map 1c
Atlantic, April-June



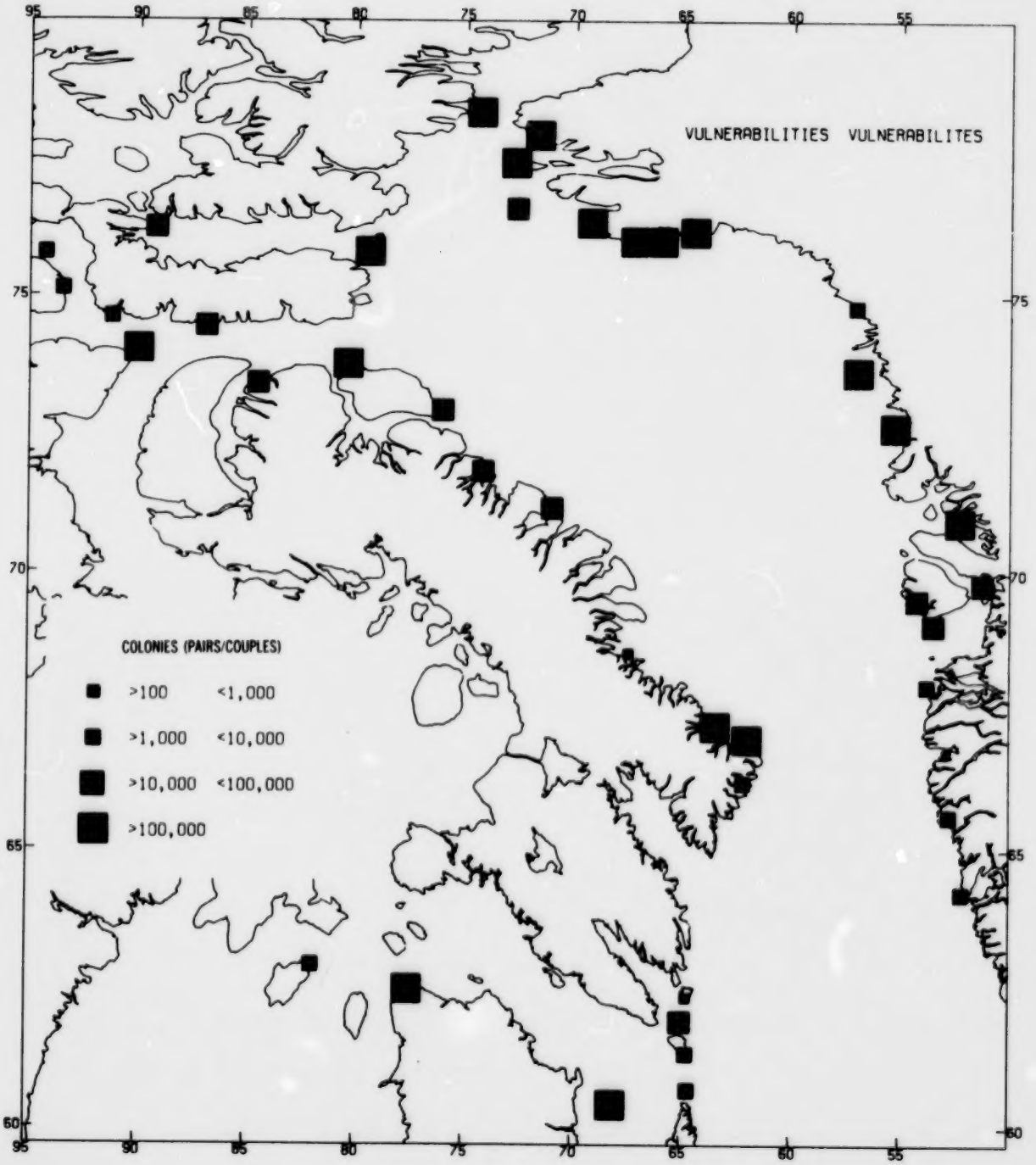
Map 1d
Atlantic, July–September



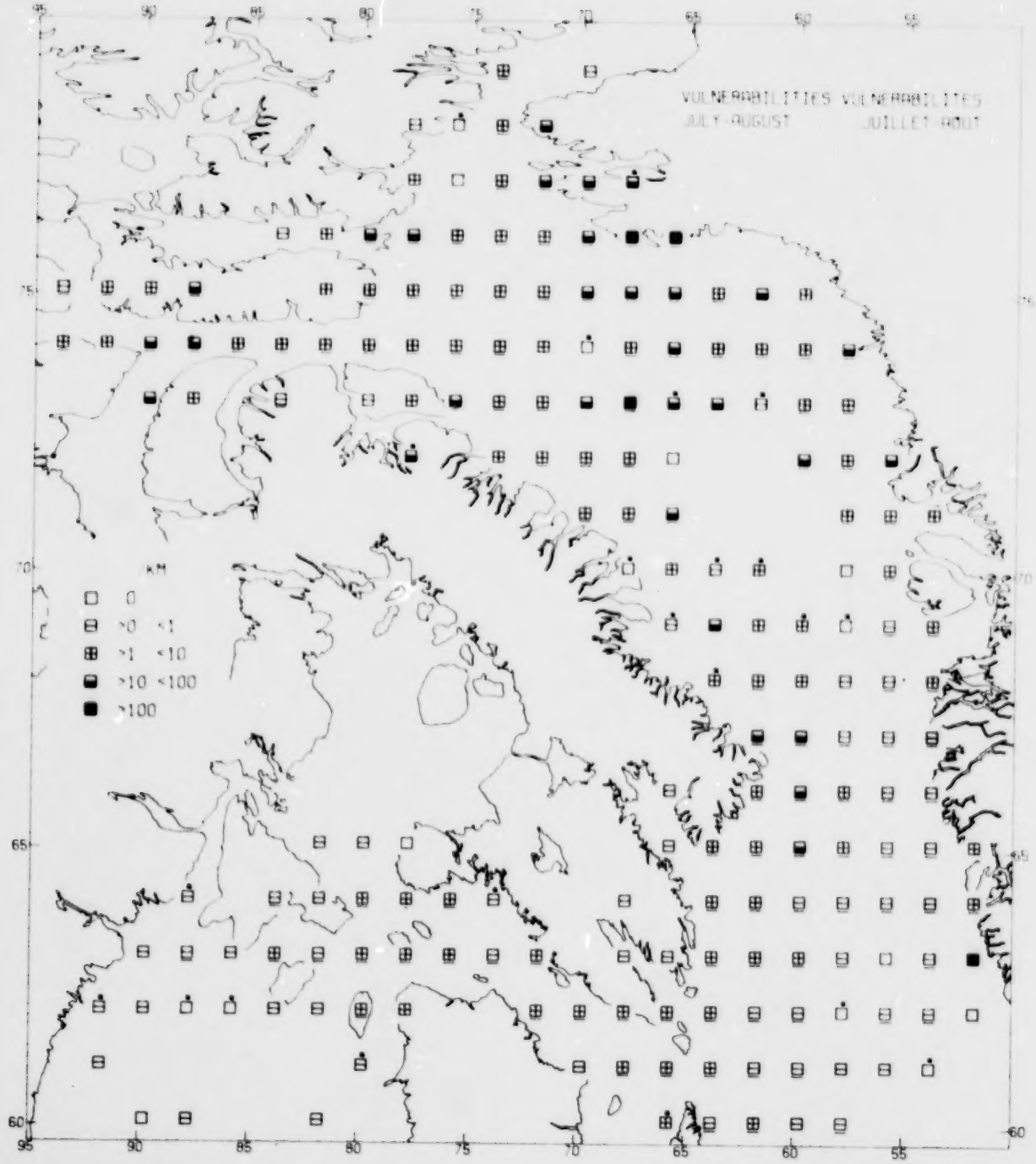
Map 1e
Atlantic, October–December



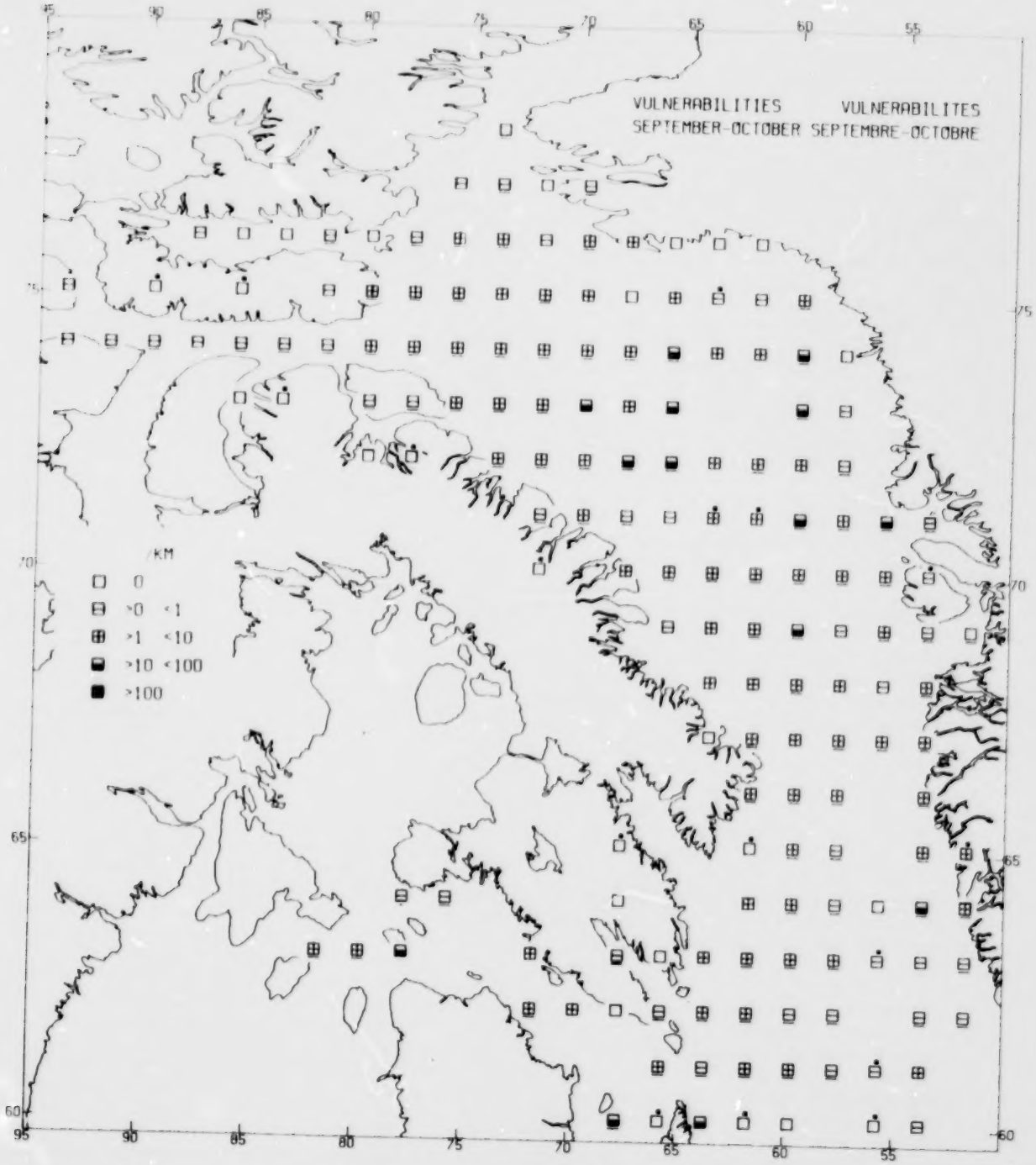
Map 1f
Arctic colonies



Map 1g
Arctic, July–August



Map 1h
Arctic, September-October



5. Species accounts

5.1. Northern Fulmar (*Fulmarus glacialis*) (Maps 2a–g)

5.1.1. Breeding distribution

The Atlantic population of the Northern Fulmar is of the order 3 million pairs. The species breeds in the Canadian Arctic (c. 350 000 pairs), Atlantic Canada (<100), west Greenland (c. 190 000), Iceland (order 100 000–1 million), Britain and Ireland (c. 306 000), Norway (1100), and Svalbard (order 1 million). There are small populations in Brittany and Heligoland, and ones of unknown size on Jan Mayen in east Greenland, the Faeroes, Franz Josef Land, and northern Novaya Zemlya. A separate subspecies breeds in the North Pacific (Salomonsen 1950, Fisher 1952, Cramp *et al.* 1974, Nettleship and Montgomerie 1974, Brown *et al.* 1975*a*, Cramp and Simmons 1977, Norderhaug *et al.* 1977, Montevecchi *et al.* 1978, Petersen 1982). The principal colonies in the eastern Canadian Arctic and west Greenland are shown in Map 2e.

The birds breeding in western Europe, Faeroe, Iceland, Jan Mayen, west Greenland, and Atlantic Canada are almost entirely of the Light colour-morph—Fisher's (1952) "LL". The birds of both the Canadian and European High Arctic are mainly of the Dark morph—Fisher's "L", "D", and "DD". Light-morph fulmars have increased their range dramatically in the temperate eastern Atlantic since the middle of the 18th century (Fisher 1952, Cramp and Simmons 1977). They were breeding at only four known sites in 1760, three in Iceland and one in Scotland, but they have colonized the whole of Iceland, Faeroe, Britain, and Ireland since then, and have recently reached Brittany and Norway. The pattern of this expansion suggests that it began in Iceland. Salomonsen (1979*b*) was probably correct in suggesting that the colonizations of southwest Greenland in c. 1945, and of Newfoundland in c. 1970, were westward extensions of this process, though a southward invasion from the Light-morph colonies in northwest Greenland cannot be ruled out. Fisher (1952) attributed it to the birds' exploitation of offal, first from whaling and then from the expanding fisheries, but this has been disputed. Salomonsen (1965) and Brown (1970) acknowledged the importance of offal as a source of food for fulmars, but suggested that oceanographic factors have been of primary importance in the species' expansion.

Adult fulmars in Britain remain on or near their colonies for much of the year (Cramp and Simmons 1977). In northwest Greenland, however, they do not return until April, and lay at the end of May or early in June. Lancaster Sound birds begin to lay in early June. The chicks hatch in late July and fledge in the first half of September (Salomonsen 1950, 1967; Cramp and Simmons 1977; D.N. Nettleship, CWS, pers. commun.).

5.1.2. Pelagic distribution

(*a*) General

Banding returns show that the Light-morph fulmars found in Atlantic Canadian waters are mainly subadult birds from colonies in west Greenland and the eastern Atlantic (Fisher 1952; Salomonsen 1967, 1971*a*, *b*, 1979*c*; Tuck 1971). Ten birds, banded in west Greenland and recovered in Newfoundland mainly in September–October, were all less than 2 years old. Their passage south may be very rapid; one newly fledged juvenile, recovered off Newfoundland in early September, had been banded on the nest only 14 days earlier. Older west Greenland fulmars have been recovered from Biscay and Portugal; 23 British-banded birds, aged 1–4 years, have been recovered in Atlantic Canada over most months of the year, and British fulmars have also been recovered off west Greenland. Analysis of the British banding recoveries as a whole suggests that these fulmars do not have a directed migration so much as a dispersal away from the breeding area, in which the younger subadults with no ties to their colonies are able to travel furthest, to Canadian and Greenland waters (Macdonald 1977). Banding in Greenland has shown that subadult fulmars rarely return to their colonies before they are 3 years old (Salomonsen 1967).

Virtually nothing is known about the movements of fulmars from High Arctic colonies. The bill-measurements of a sample of Dark-morph birds, collected in spring off Labrador, suggested that these had come from the European, not the Canadian, Arctic (Brown 1973*b*).

(*b*) *Atlas* maps: Atlantic

In January–March fulmars occur commonly on Georges Bank south to c. 40°N, with stragglers farther south (Powers 1983). The *Atlas* maps show that they are uncommon on the Scotian Shelf, but abundant on the Grand Banks and at the edge of the Shelf off northeast Newfoundland and southeast Labrador. This distribution pattern is maintained in April–June, though the birds have largely withdrawn from Georges Bank by the beginning of May. There is a definite withdrawal from the southern Grand Bank in June–July, but Fulmars begin to return there in August. By October–December there are large numbers off southeast Labrador and northeast Newfoundland, and on the northern Grand Bank as far east as Flemish Cap.

(*c*) *Atlas* maps: Arctic

It is probable that few, if any, fulmars winter in Baffin Bay because of extensive ice-cover (Anon. 1958), but they have returned by the beginning of May. Aerial surveys (McLaren 1982) showed an influx of birds into northwest Baffin Bay in May, and another that began in June and peaked in early July. It is probable that these represented the arrival of the breeding and subadult birds respectively. Further south, other aerial surveys showed fulmars to be common off northern Labrador in April–May, but not west of c. 61°W in Hudson Strait; they moved further west into the strait, on both the Labrador and Baffin Island sides, in June (MacLaren 1978, 1979). Fulmars are common in the channels around Killinek and the Button Islands off Labrador in July–August (see also Gross 1937), remaining there at least as late as early November.

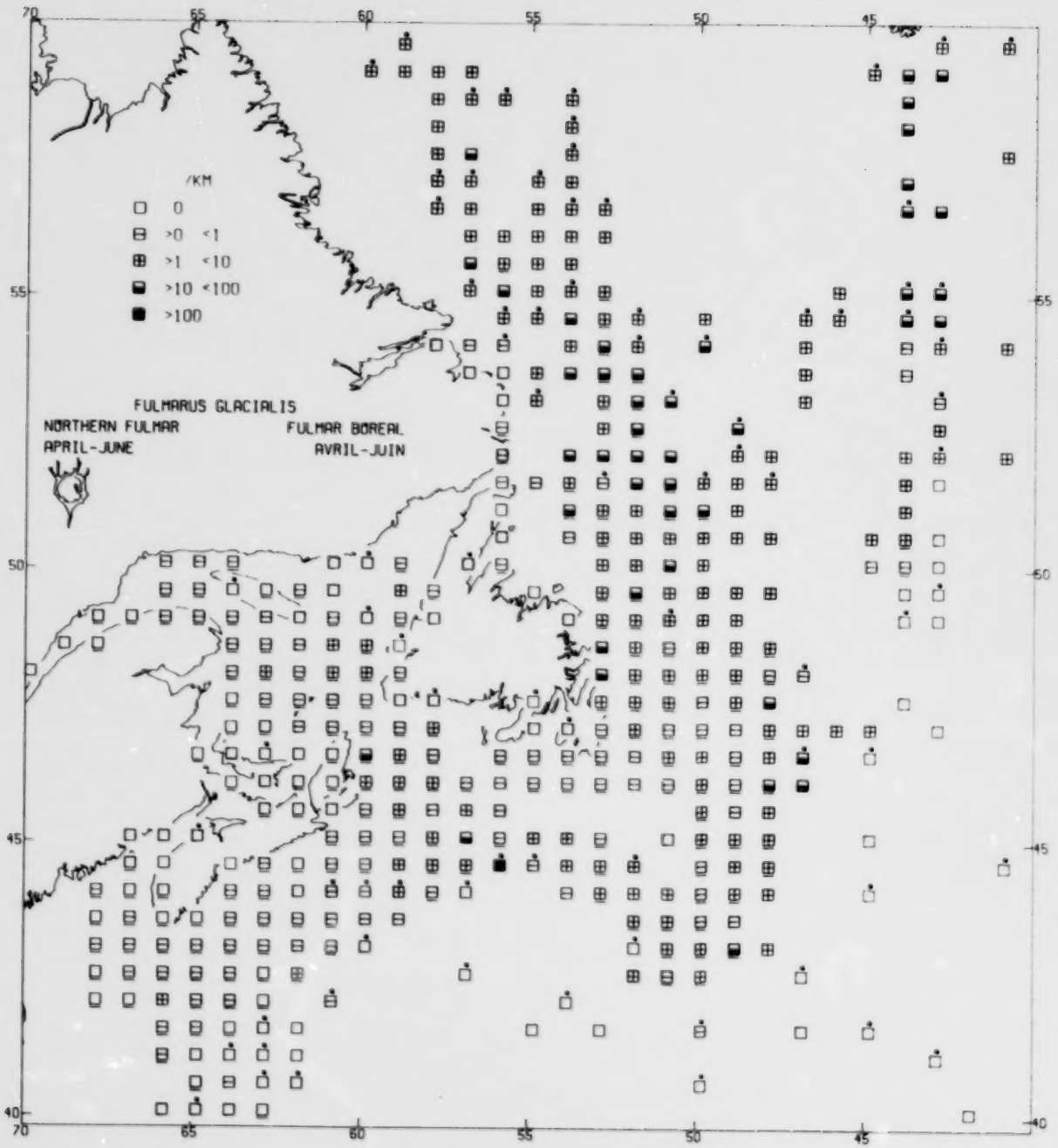
Fulmars are widespread throughout Baffin Bay and Davis Strait in July–August, but occur only at the eastern entrance to Hudson Strait. They appear to withdraw from northern Baffin Bay in September, presumably as the young birds fledge from the colonies.

Maps 2a–g

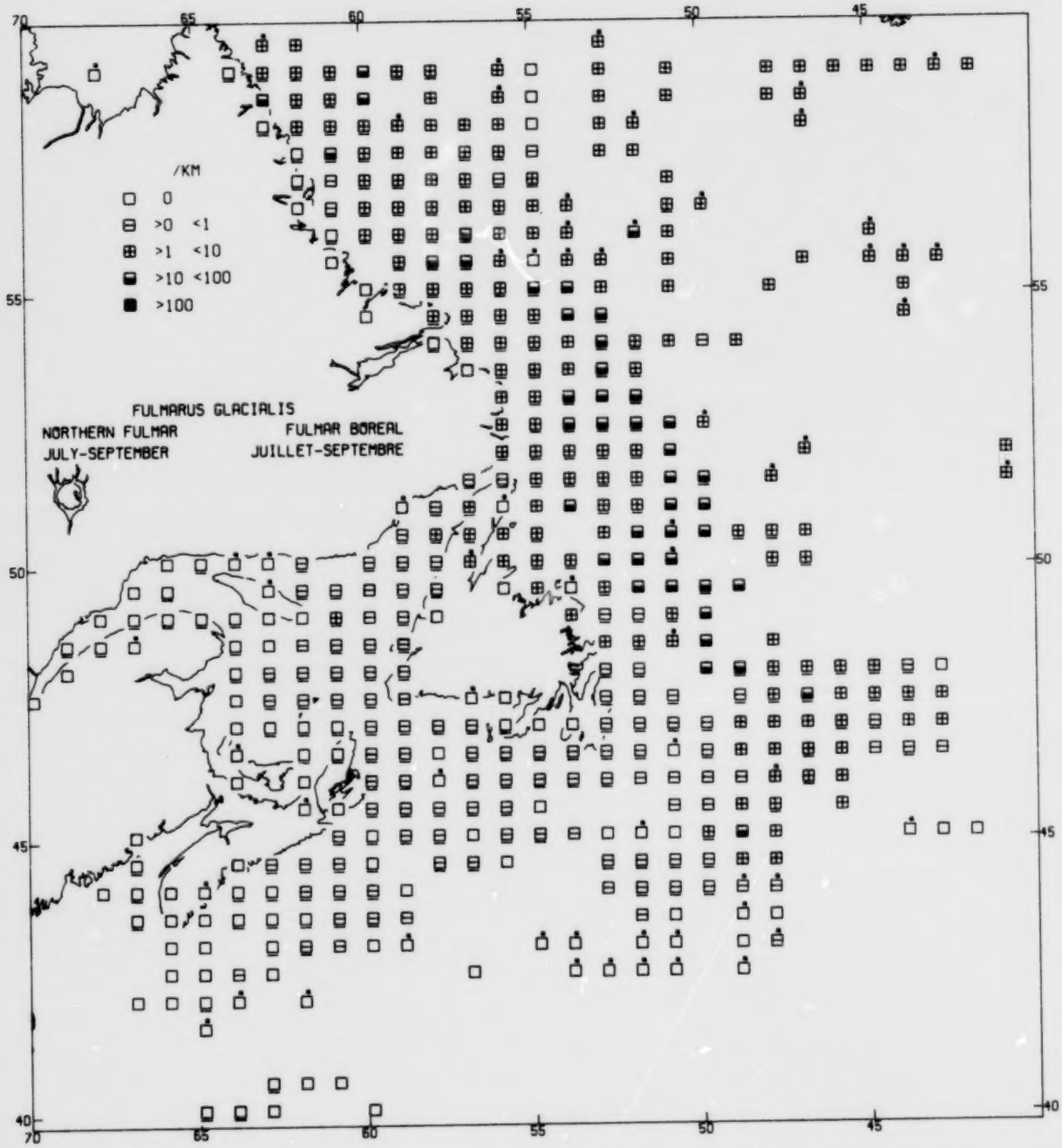
Northern Fulmar distributions

Map 2a
Atlantic, January–March

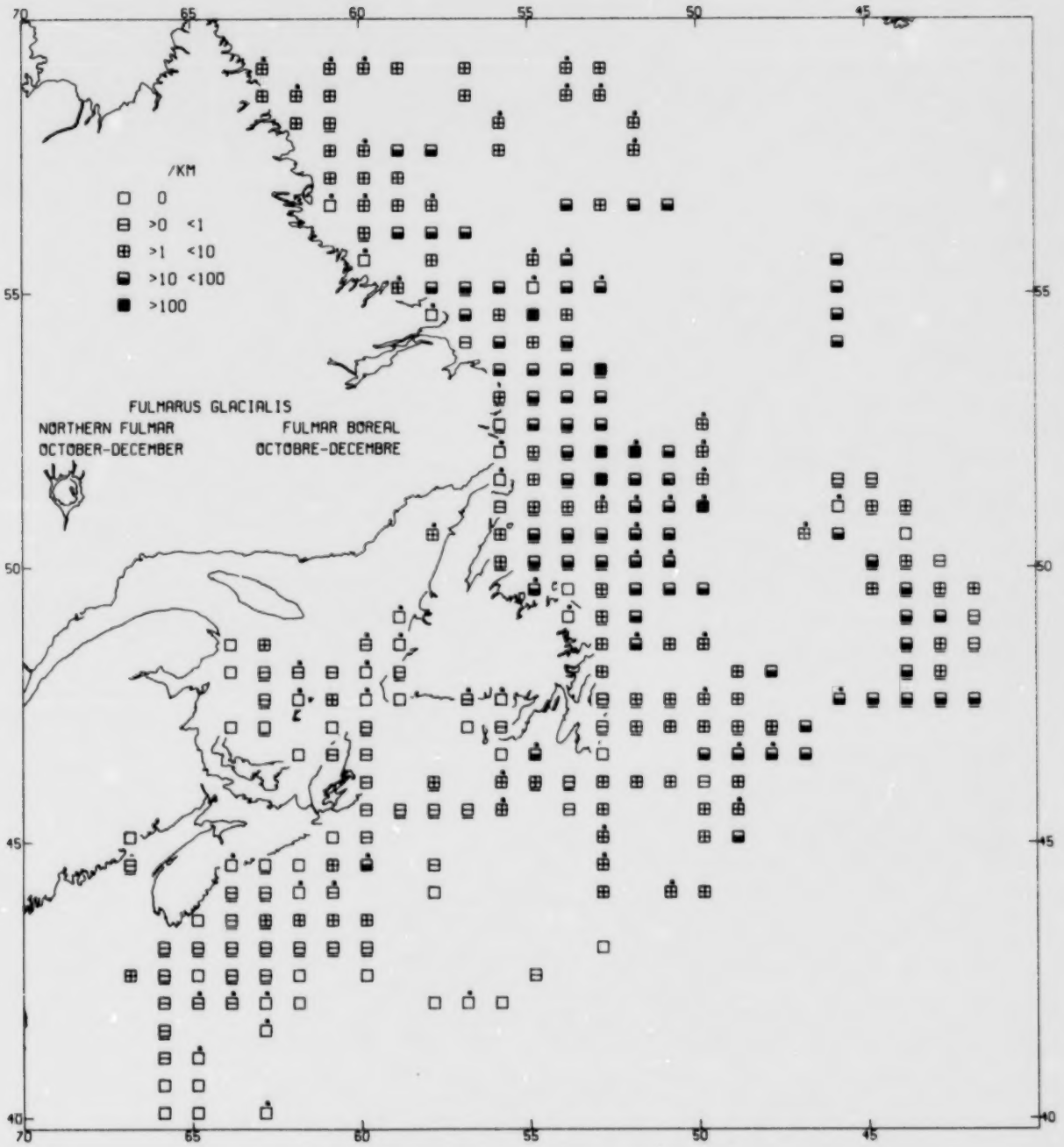
Map 2b
Atlantic, April–June



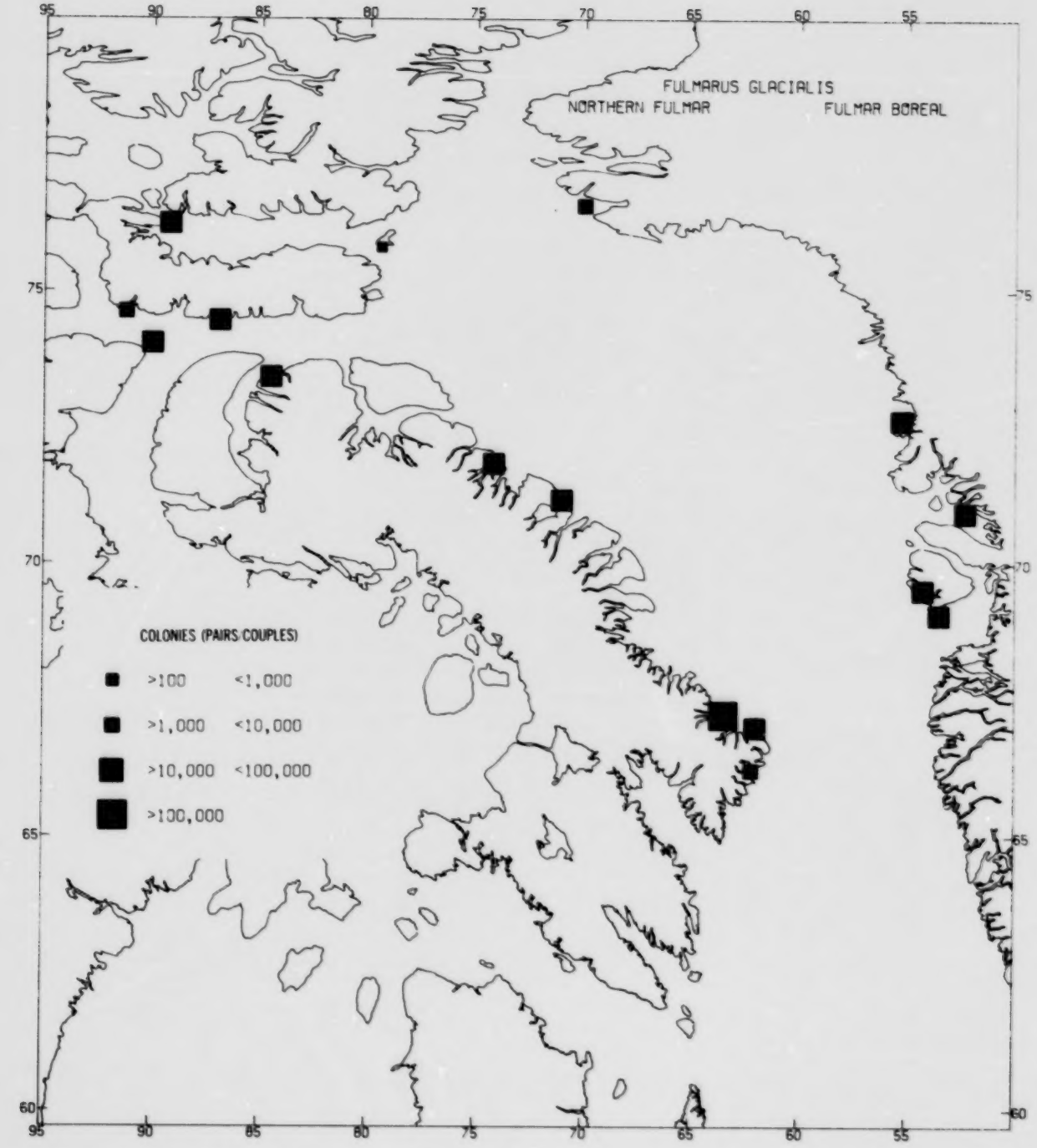
Map 2c
Atlantic, July–September



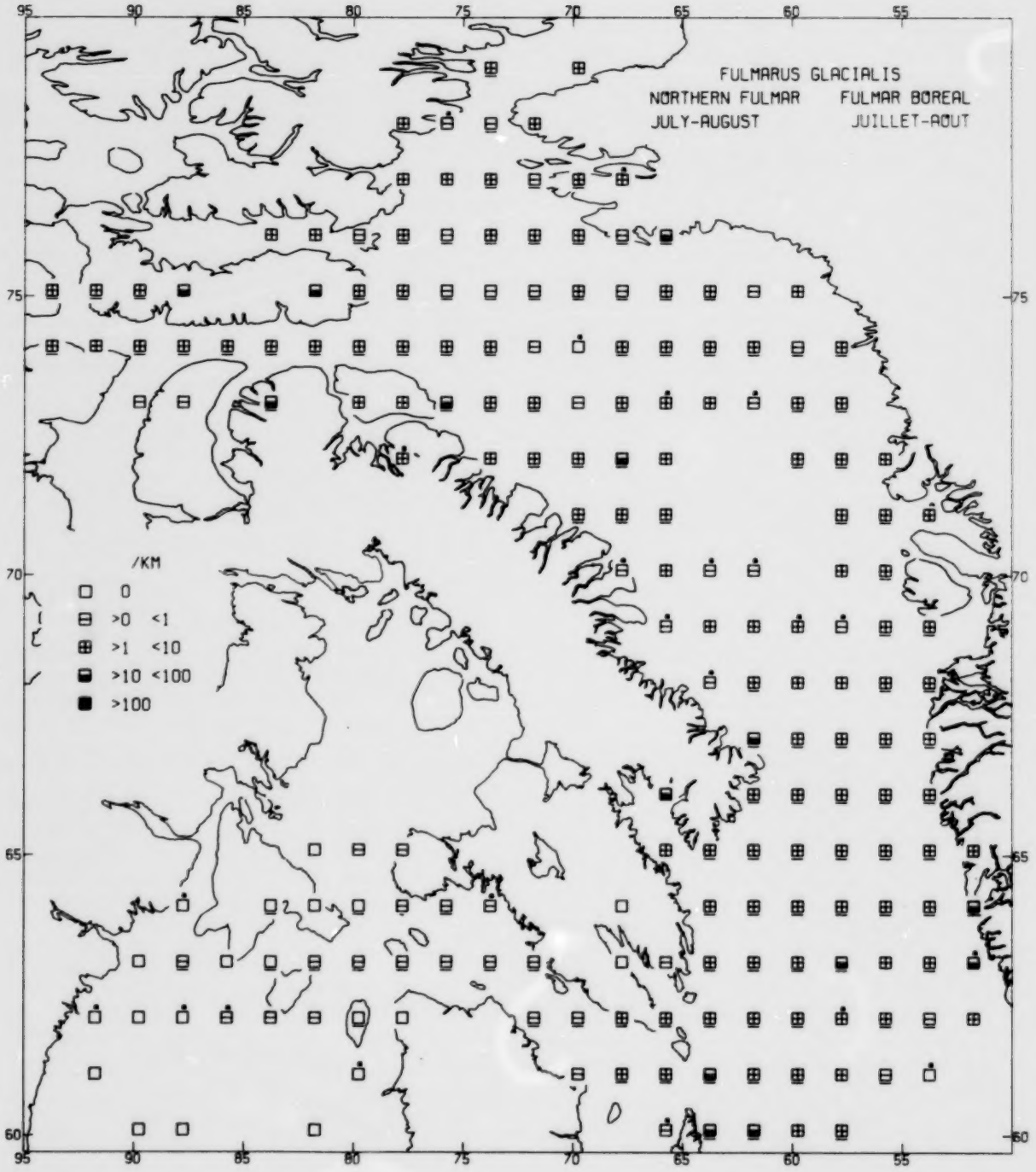
Map 2d
Atlantic, October–December



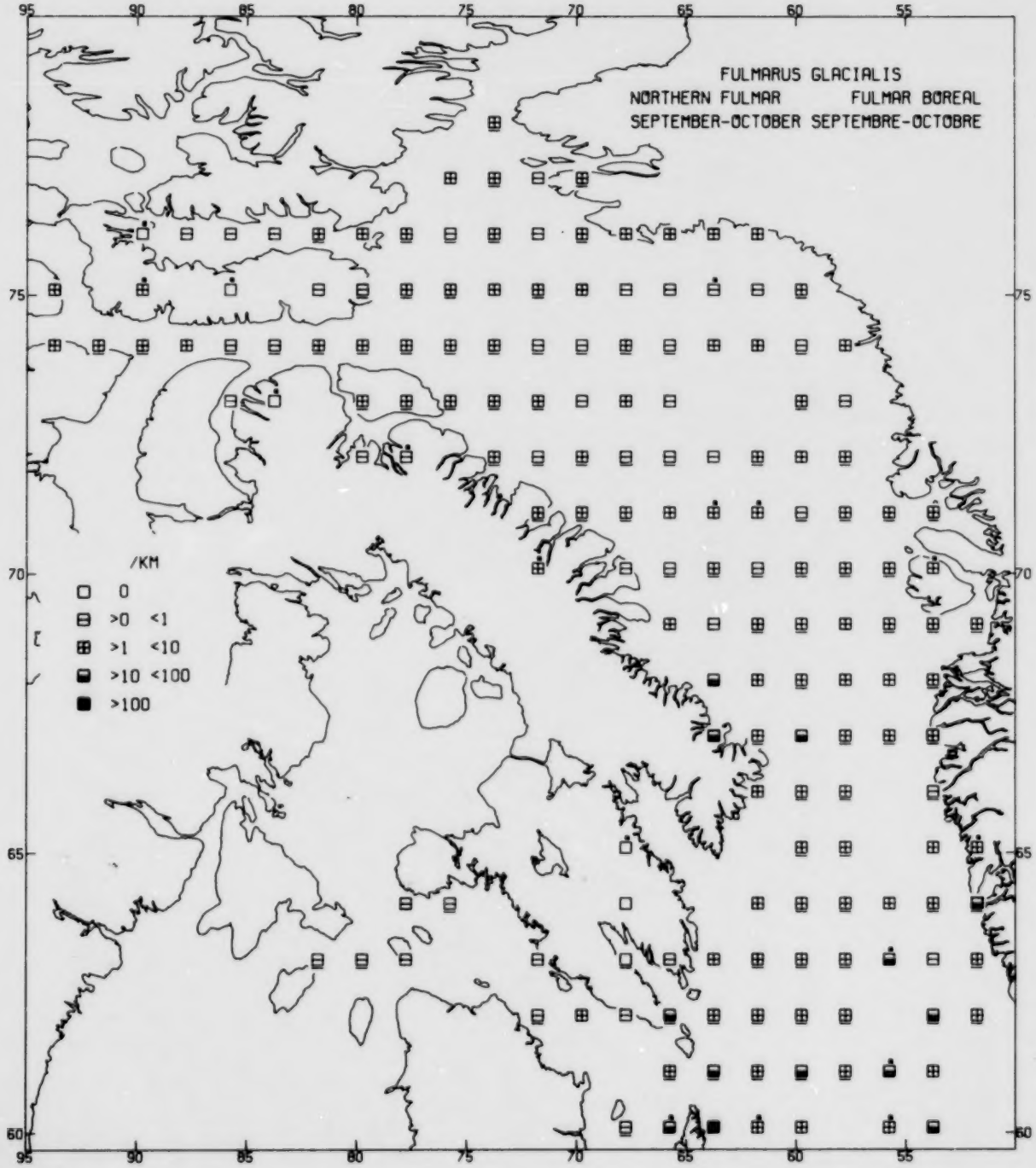
Map 2e
Arctic colonies



Map 2f
Arctic, July–August



Map 2g
Arctic, September–October



5.2. Greater Shearwater (*Puffinus gravis*) (Maps 3a–c)
Sooty Shearwater (*Puffinus griseus*) (Maps 4a,b)

5.2.1. Breeding distributions

Greater and Sooty Shearwaters breed only in the Southern Hemisphere, and migrate to the North Atlantic during the southern winter. Greater Shearwaters breed mainly on Tristan da Cunha and Gough Island in the South Atlantic, with a small population in the Falklands. The world population is of the order of 2.75 million pairs (Cramp and Simmons 1977). Sooty Shearwaters breed in the Falklands, in the region of Tierra del Fuego, and off New Zealand and southeast Australia (Cramp and Simmons 1977). The size of the world population is unknown, but is undoubtedly large; Warham and Wilson (1982) estimated 2.75 million pairs at one New Zealand colony alone.

The breeding cycles of these two shearwaters are similar. Greater Shearwaters return to Tristan da Cunha in the middle of September and lay in mid-November; the chicks hatch early in January (Rowan 1952, Palmer 1962, Cramp and Simmons 1977). The adults abandon the colony in April, but the young birds remain at least until the middle of May. At New Zealand colonies, Sooty Shearwaters return in late September and lay in late November; the chicks hatch in mid-January and fledge at the end of April, but the adults begin to leave in late March (Palmer 1962, Richdale 1963, Cramp and Simmons 1977, Warham *et al.* 1982). Falklands adults may not return until mid-October; they leave in late March, and most of the juveniles follow in the first half of April (Woods 1975).

5.2.2. Pelagic distributions

(*a*) General

Virtually the whole of the Greater Shearwater population winters in the North Atlantic, from Georges Bank to southern Greenland (Hagen 1952; Salomonsen 1950, 1967, 1971*b*; Palmer 1962; Voous and Wattel 1963; Reinsch 1967; Stresemann and Stresemann 1970; Gräfe 1973; Brown *et al.* 1975*a*; Cramp and Simmons 1977). The adult birds migrate up the western side of the Atlantic, past the northeast corner of Brazil, and reach Georges Bank and the southern Grand Bank at the end of May. They then undergo a very rapid moult of the flight feathers, which does not, however, leave them flightless. After this, they move north up the east coast of Newfoundland to southwest and southeast Greenland. Juvenile and subadult birds arrive in the North Atlantic in July; it may be these subadults that make up the large flocks of moulting birds found off southwest Greenland in August. The return passage to the Southern Hemisphere takes place down the east-central Atlantic, and also off the east coast of North America at least as far south as 40°N. It is possible that the latter route is taken mainly by subadults; the flock of c. 200 000 birds seen on Georges Bank, off New England (c. 41°30′N) on 11 November 1977 (Powers and Van Os 1979) must, at that late date, have been made up of non-breeders.

The principal winter quarters of the Sooty Shearwater are in the North Pacific and off Peru (Murphy 1936, Palmer 1962, Phillips 1963, Jehl 1974*a*, Brown *et al.* 1975*a*, Cramp and Simmons 1977, Blake *et al.* 1984). The species is relatively rare in the North Atlantic; perhaps as many Sooty Shearwaters overwinter in the South Atlantic as migrate north. Some, perhaps all, of our birds come from the Falklands; a juvenile banded there on 3 May 1962 was recovered in Barbados 28 days later, presumably en route to our waters (Woods 1975). They first arrive off New England and Newfoundland in late April, move rapidly up the Labrador coast, and across the Atlantic at latitudes south of Greenland. Few remain in the western Atlantic by the beginning of September. They reach British waters in July and remain there until October, when they return to the Southern Hemisphere, presumably via the eastern Atlantic.

(*b*) *Atlas* maps: Atlantic

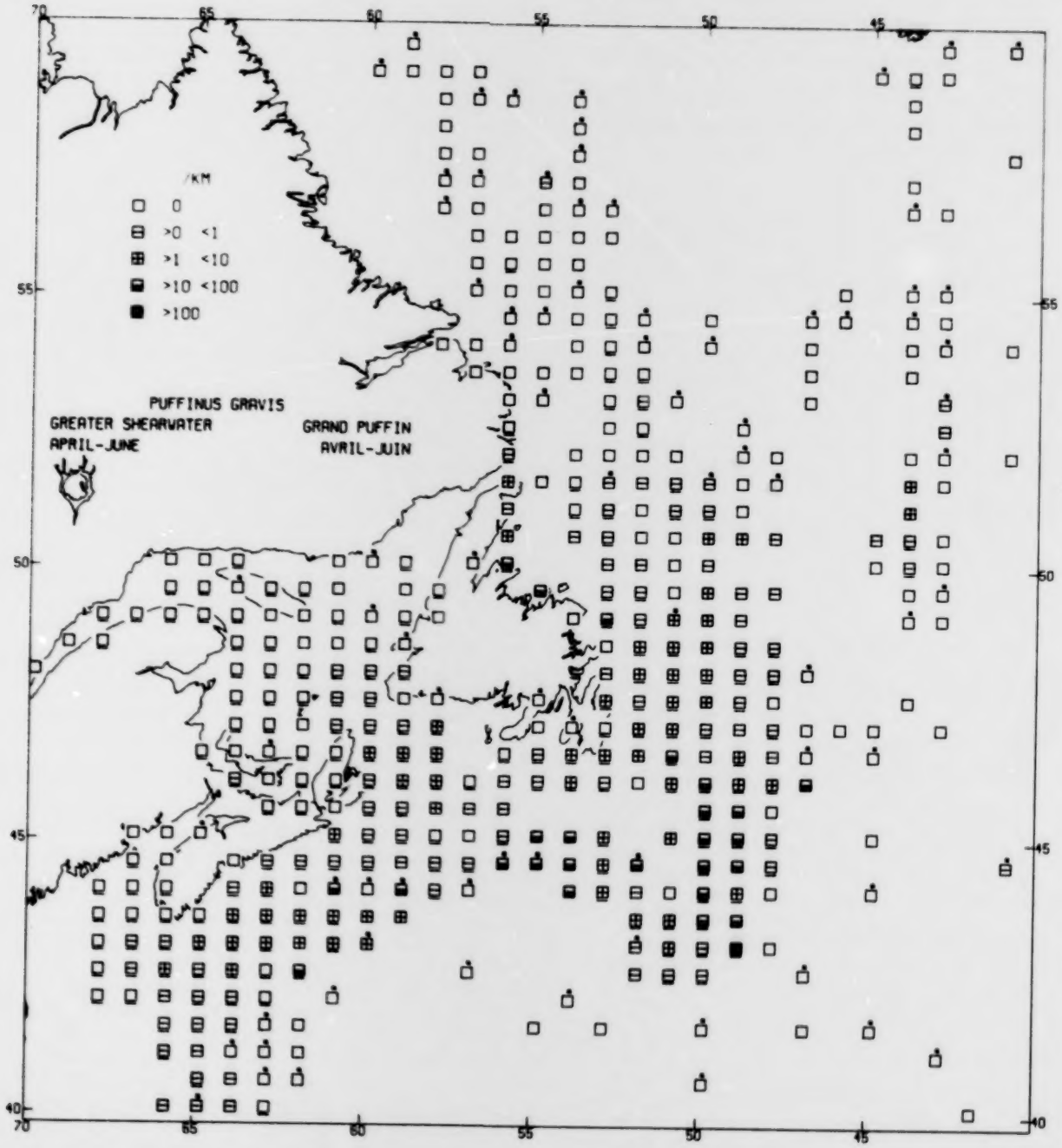
Greater Shearwaters reach the southern Grand Bank and the Scotian Shelf in late May. They are abundant there in June–July; this is also the time of the first peak in numbers on Georges Bank, where the birds are abundant north of c. 40°N (Powers 1983). They spread north into eastern Newfoundland waters and have reached the Strait of Belle Isle by early July. They are common along the outer edge of the Labrador Shelf in August, cross to the east side of Davis Strait and move up the west Greenland coast as far as c. 66°N (Brown *et al.* 1975*a*). A few remain off west Greenland in September, and numbers are beginning to thin out on the Grand Banks by then. Greater Shearwaters are found mainly on the Grand Banks and Scotian Shelf in October, and there is also a second peak of abundance on Georges Bank at that time. Small flocks are still present off eastern Newfoundland in November, and large local concentrations remain on Georges Bank (Brown *et al.* 1975*a*, Powers and Van Os 1979). Greater Shearwaters have occasionally been seen in February (e.g. Brown 1977, Powers 1983), presumably either overwintering birds or very early migrants.

Sooty Shearwaters arrive on the southern Grand Bank and the Scotian Shelf in May. They also reach the northern part of Georges Bank, where peak numbers are recorded in June (Powers 1983). The April–June map (Map 4a) shows that they occur off eastern Newfoundland as far north as the Strait of Belle Isle, apparently only in very small numbers. However, that shortage arises from the scarcity of inshore coverage; as many as 100 000 Sooty Shearwaters have been seen inshore in Placentia Bay, southern Newfoundland, in mid-June (Brown *et al.* 1981). The birds are still on the Scotian Shelf and Grand Bank in July; by then they have reached northern Labrador, where they seem to occur closer inshore than do the Greater Shearwaters. A few birds remain in the Bay of Fundy and on the Scotian Shelf and Georges Bank in August (see also Brown *et al.* 1981), though they are becoming scarce on the Grand Banks; they have almost abandoned Canadian Atlantic waters by early September. Stray birds are occasionally seen in the southern Labrador Sea as late as November (unpubl. CWS *Atlas* files).

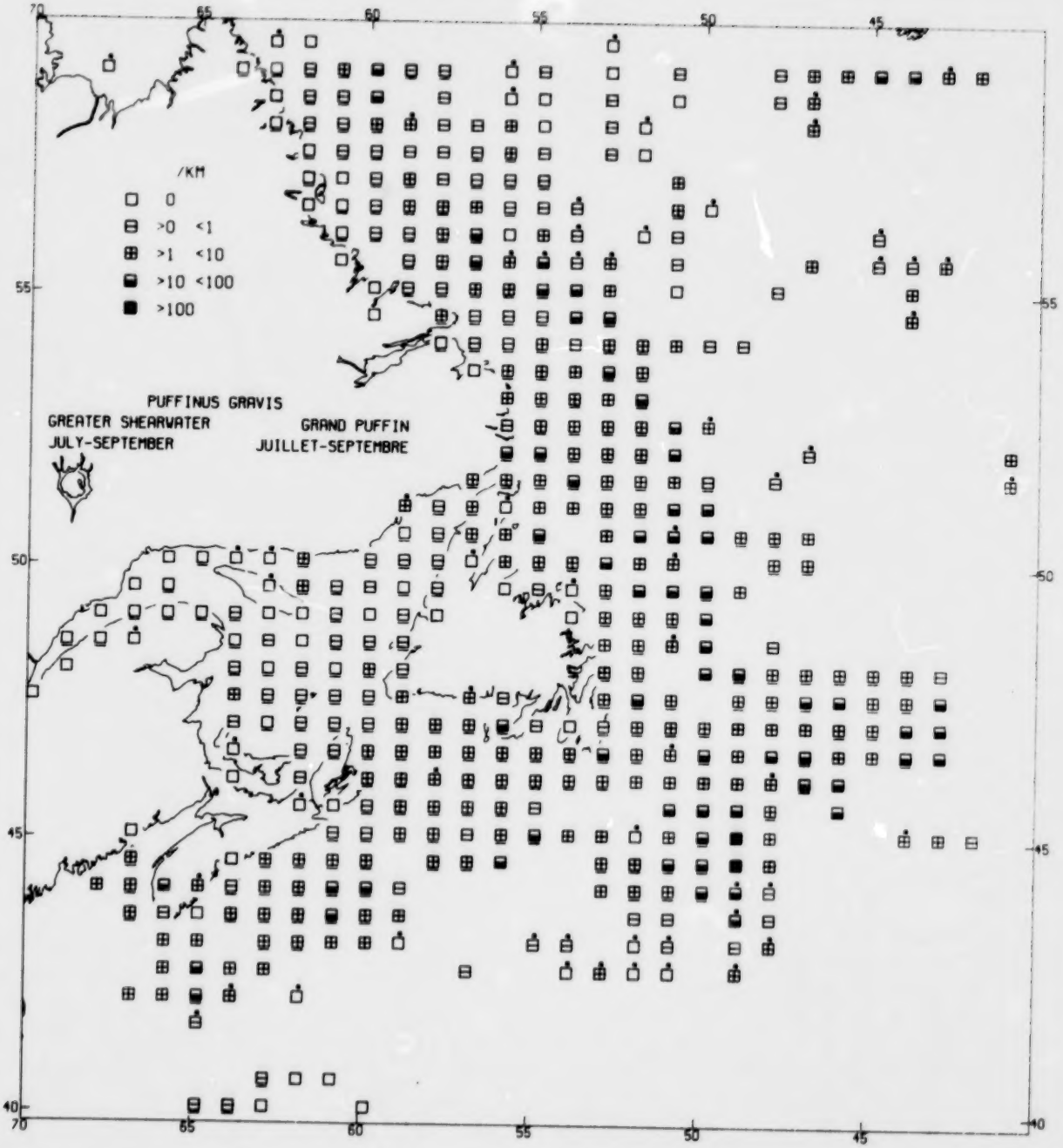
Maps 3a–c

Greater Shearwater distributions

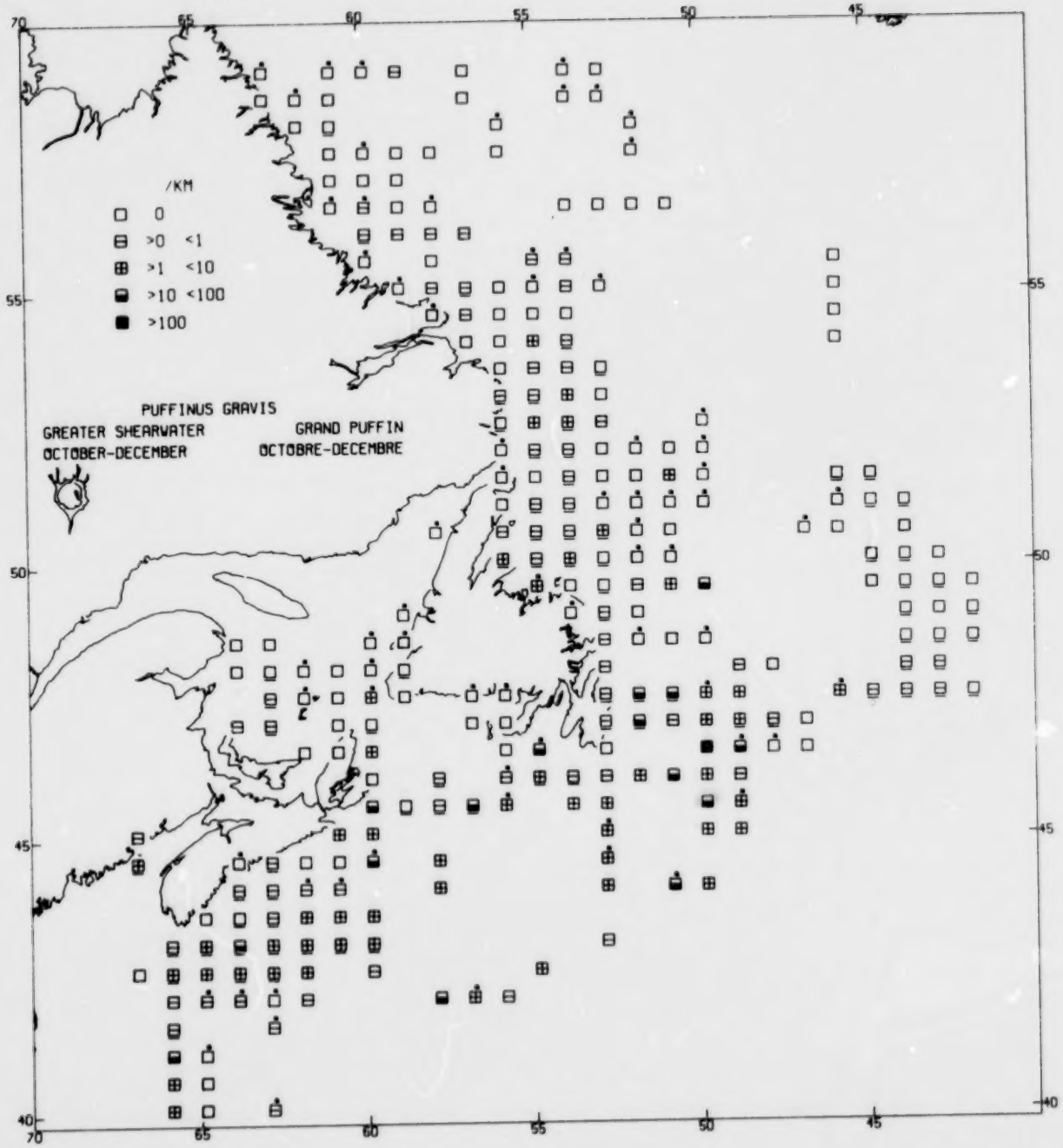
Map 3a
Atlantic, April–June



Map 3b
Atlantic, July–September



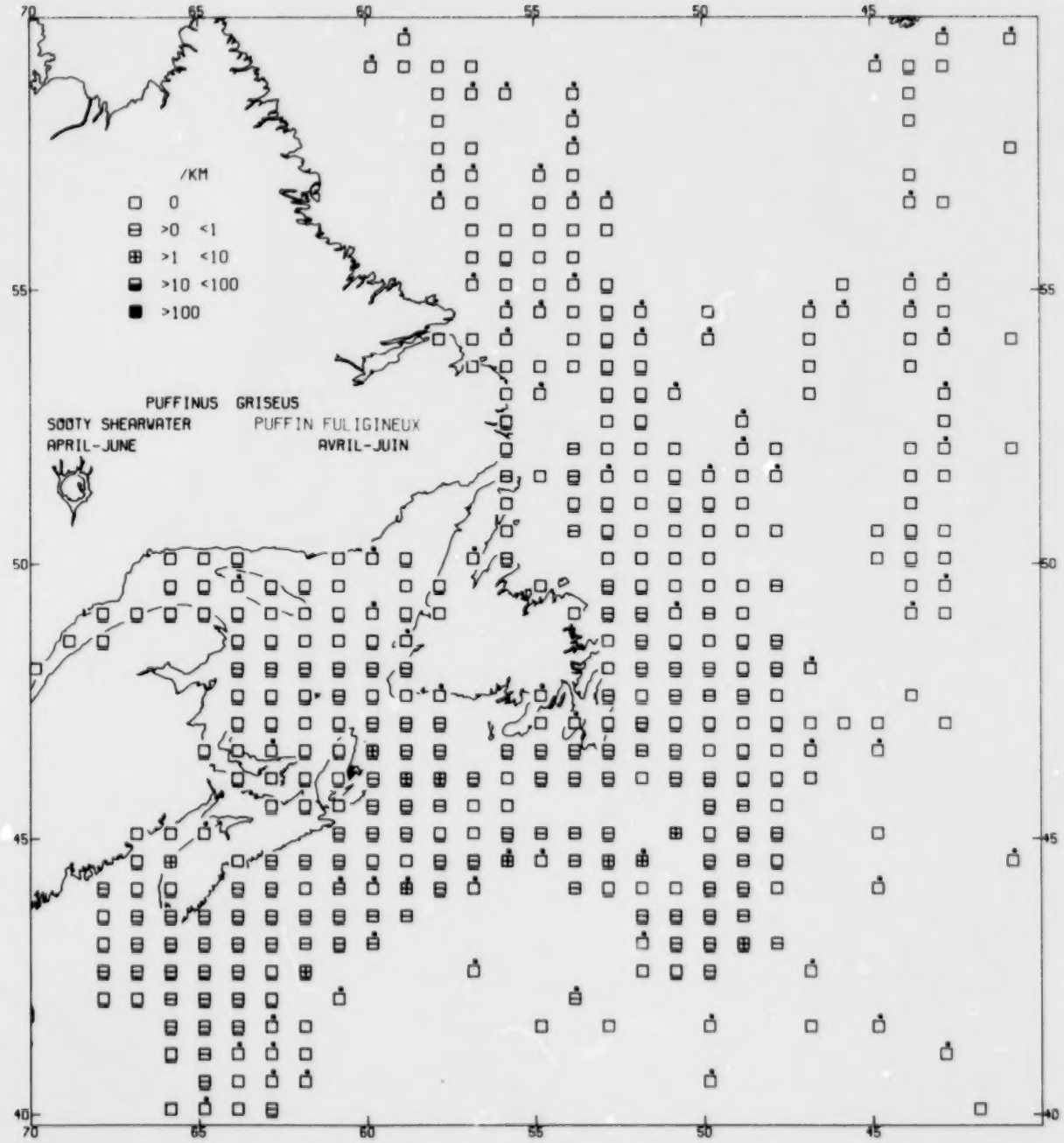
Map 3c
Atlantic, October–December



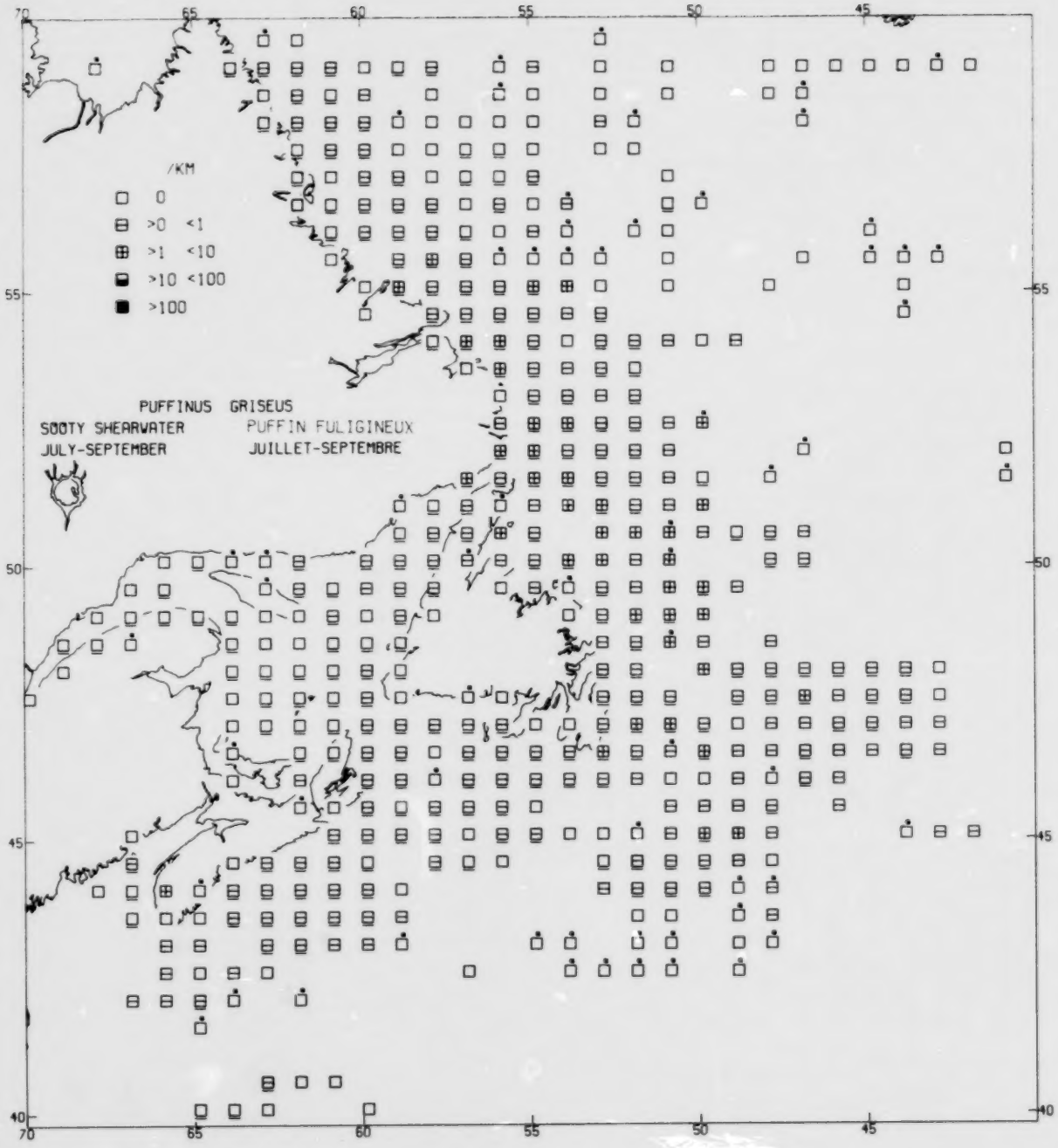
Maps 4a–b

Sooty Shearwater distributions

Map 4a
Atlantic, April–June



Map 4b
Atlantic, July–September



5.3. Manx Shearwater (*Puffinus puffinus*)
Audubon's Shearwater (*Puffinus lherminieri*)
Little Shearwater (*Puffinus assimilis*)
Cory's Shearwater (*Calonectris diomedea*)

The only shearwater that breeds within the area covered by this *Atlas* is the Manx Shearwater. A single nest was discovered in Massachusetts in 1973 (Bierregaard *et al.* 1975), and c. 100 pairs colonized an island off southern Newfoundland in 1975 (Storey and Lien 1985). One of the Newfoundland birds had been banded as a chick in Wales. Manx Shearwaters are regularly seen in summer, in small numbers, off New England and Atlantic Canada north to c. 50°N (Post 1967, Brown *et al.* 1975*a*, Brown 1977); they are commonest in July–August. The species has only once been recorded from Greenland (Salomonsen 1967). Almost all the birds belong to the subspecies *P.p.puffinus*, which breeds in the eastern Atlantic from Iceland south to Madeira, and are presumably subadults returning from winter quarters off southeast Brazil (Cramp and Simmons 1977).

Audubon's Shearwater breeds in the Bahamas, the West Indies, and elsewhere in the tropical Atlantic and Pacific (Palmer 1962). It is regularly seen in summer in the warmer waters off eastern North America: for example, east of the shelf-break off the Mid-Atlantic Bight (c. 35°N), and in the *Gulf Stream* east of Georges Bank (e.g. Brown *et al.* 1975*a*; Brown 1977, 1980*c*; Powers 1983). The closely related Little Shearwater, which in the North Atlantic breeds only on the Azores, Madeira, Canaries, and Cape Verde Islands, has been collected once, on Sable Island, but probably also reaches the Grand Banks (Godfrey 1966, Brown 1972, Cramp and Simmons 1977).

Cory's Shearwater is a large, subtropical species that breeds from the Azores to the Cape Verdes, and in the Mediterranean (Cramp and Simmons 1977). It occurs in small numbers on Georges Bank, especially south of c. 41°N, and in the *Gulf Stream/North Atlantic Drift* from the outer edge of the Scotian Shelf to the eastern edge of the Grand Banks (Brown *et al.* 1975*a*, Brown 1977, Powers 1983), and has been observed from May to November. Most sightings are in July–August, during the breeding season, and must therefore be of subadult birds—probably en route to the eastern Atlantic from their wintering area off South Africa, by way of the waters off Uruguay (Cramp and Simmons 1977). Most of the birds found off eastern North America appear to be *C.d.borealis*, the subspecies breeding on the Azores, Canaries, and Madeira, but the Mediterranean subspecies *C.d.diomedea* has also been recorded (Palmer 1962, Forsythe 1980).

5.4. Leach's Storm-Petrel (*Oceanodroma leucorhoa*) (Maps 5a,b)
Harcourt's Storm-Petrel (*Oceanodroma castro*)
Wilson's Storm-Petrel (*Oceanites oceanicus*) (Maps 6a,b)
British Storm-Petrel (*Hydrobates pelagicus*)

5.4.1. Breeding distributions

Leach's Storm-Petrel breeds in temperate areas of the North Atlantic and North Pacific, including both the east and west coasts of Canada. The North Atlantic population is of the order of 1 million pairs, the majority of which breed in eastern Newfoundland. Smaller numbers breed from southeast Labrador south to New England, in southwest Iceland, Faeroe, northern Scotland, and Norway. The birds arrive at their colonies in Atlantic Canada at the beginning of May and lay their single eggs from early June onwards. The chicks do not fledge until October, or even later (Palmer 1962, Cramp *et al.* 1974, Brown *et al.* 1975*a*, Cramp and Simmons 1977).

Wilson's Storm-Petrel is an Antarctic and Subantarctic species which migrates into the Indian, North Pacific, and North Atlantic Oceans during the southern winter. It breeds in the Falklands, Tierra del Fuego, and Antarctica and the Subantarctic islands. The world population is unknown, but is undoubtedly very large. The birds return to their colonies in the Antarctic in November–December and lay their single eggs in December–January. The chicks hatch in January–March, and abandon the colony in March–May. Laying in the Falklands probably takes place in November–December (Roberts 1940, Palmer 1962, Watson 1975, Woods 1975, Cramp and Simmons 1977).

Harcourt's Storm-Petrel is a subtropical species whose North Atlantic population breeds in Madeira, the Canaries, and the Cape Verde Islands. The British Storm-Petrel breeds from Iceland to Biscay, and in the Mediterranean, and winters off South Africa. Each has been recorded once in Canada: a British Storm-Petrel on Sable Island and a Harcourt's, presumably storm-driven, in eastern Ontario. Both species may be confused with the abundant Leach's and Wilson's Storm-Petrels, and it is likely that they visit Canadian waters more frequently than these two records suggest (Godfrey 1966, McNeil and Burton 1971, Cramp and Simmons 1977).

5.4.2. Pelagic distributions

(*a*) General

At the end of the breeding season, Leach's Storm-Petrels apparently move south to winter in the convergence zones in the tropical Atlantic (Cramp and Simmons 1977, Brown 1979). At least part of the eastern Canadian population crosses to the eastern Atlantic; a bird banded in Newfoundland has been recovered in Spain, and the massive "wrecks" of Leach's Storm-Petrels blown ashore in western Europe by autumnal gales can only have come from the large Canadian colonies (Boyd 1954). The birds reach west Africa in November and spread out into the Gulf of Guinea; some pass through the tropics and winter off South Africa. Meanwhile another passage down the west side of the Atlantic reaches the equatorial waters off Brazil in December–January.

The subspecies of Wilson's Storm-Petrel that winters off eastern North America is *O.o.exasperatus* from Antarctica and the adjacent islands (Roberts 1940). Their northward migration begins as early as March. The main movement in the Atlantic passes rapidly up the west side and reaches New England waters in April; a smaller, possibly slower migration passes up the African coast. The northern limit of their distribution rarely exceeds 50°N on either side of the North Atlantic. The return movement begins in September, with birds leaving the western Atlantic before the eastern; there may be a west to east movement of the kind shown by other transequatorial migrants such as the Greater and Sooty Shearwaters (q.v.) (Roberts 1940, Palmer 1962, Brown *et al.* 1975*a*, Cramp and Simmons 1977).

(*b*) *Atlas* maps: Atlantic

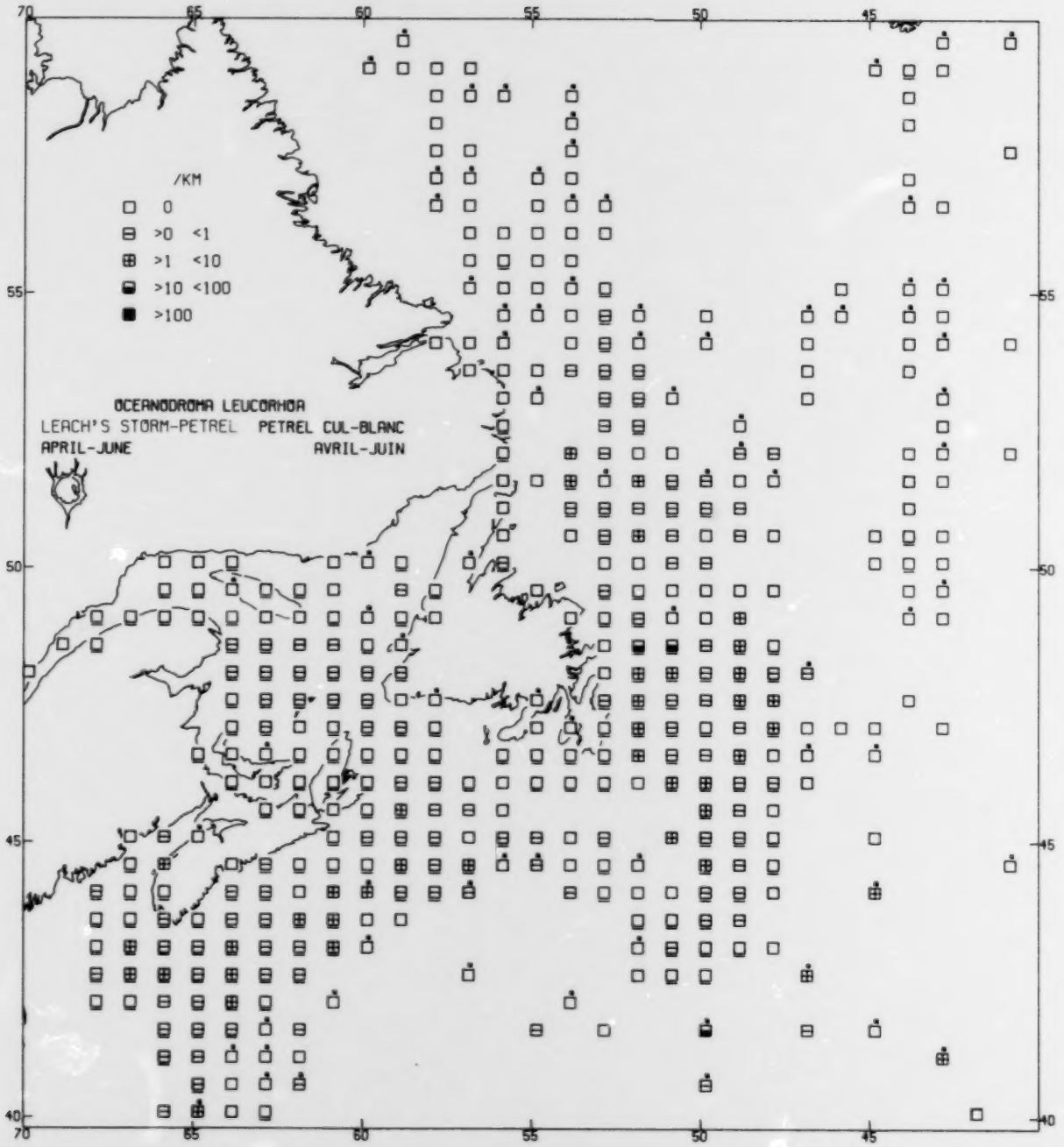
A few Leach's Storm-Petrels appear on the southern Grand Bank and Scotian Shelf as early as March, but the main arrival is in May. They are found off New England in small numbers from April to October, mainly in the deep waters south and east of Georges Bank (Powers 1983). For the rest of the summer the birds are most common close to the big colonies in southeast Newfoundland, and across the northern edge of the Grand Banks. The birds stay well offshore in the daytime; large concentrations close inshore are of birds leaving the colonies at first light. Smaller numbers occur on Georges Banks, the Scotian Shelf, the Gulf of St. Lawrence, and off southeast Labrador. Numbers start to decline in September, possibly with the departure of subadult birds (e.g. Palmer 1962, Cramp and Simmons 1977).

Wilson's Storm-Petrel is generally most common on Georges Bank and the southern Scotian Shelf and Grand Bank, with relatively few occurring off Newfoundland and farther north, although stragglers have reached the eastern end of Hudson Strait (Brown *et al.* 1975*a*). The species has not been recorded in Greenland (Salomonsen 1967). The birds reach Georges Bank in April and are extremely abundant there from May to August, especially near the edges of the bank and at the shelf-break farther south (Powers 1983). Small numbers reach the southern Scotian Shelf and Grand Bank in May, spread to the northern Grand Bank in June, and up the Labrador coast in July. By August, however, they appear to withdraw from these northern limits, and are becoming scarcer on Georges Bank and the Scotian Shelf. A few remain in September in those parts of Georges Bank, the Scotian Shelf, and the southern Grand Bank that are most influenced by the *Gulf Stream*, but the species has virtually abandoned the western Atlantic by October.

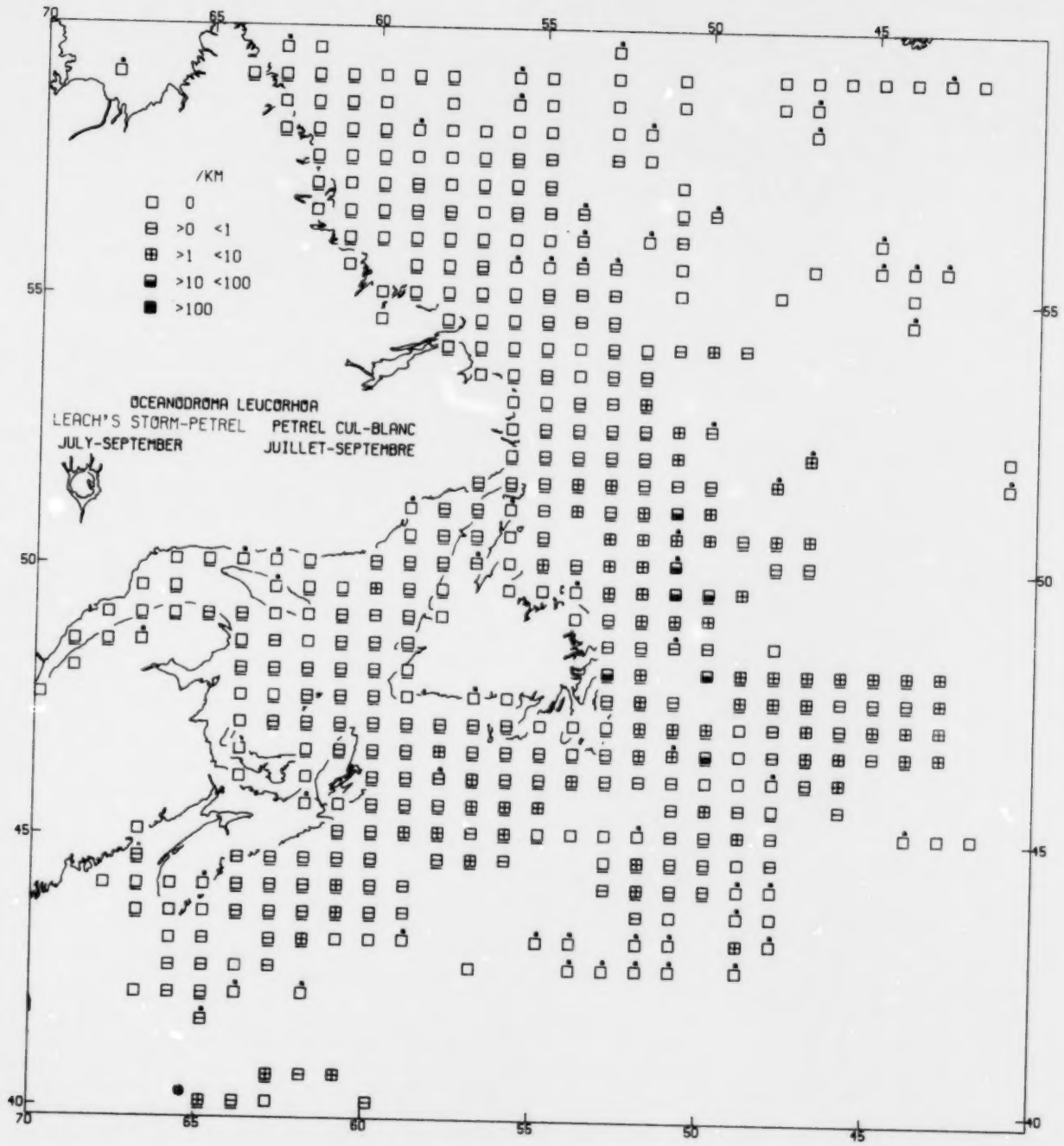
Maps 5a–b

Leach's Storm-Petrel distributions

Map 5a
Atlantic, April–June



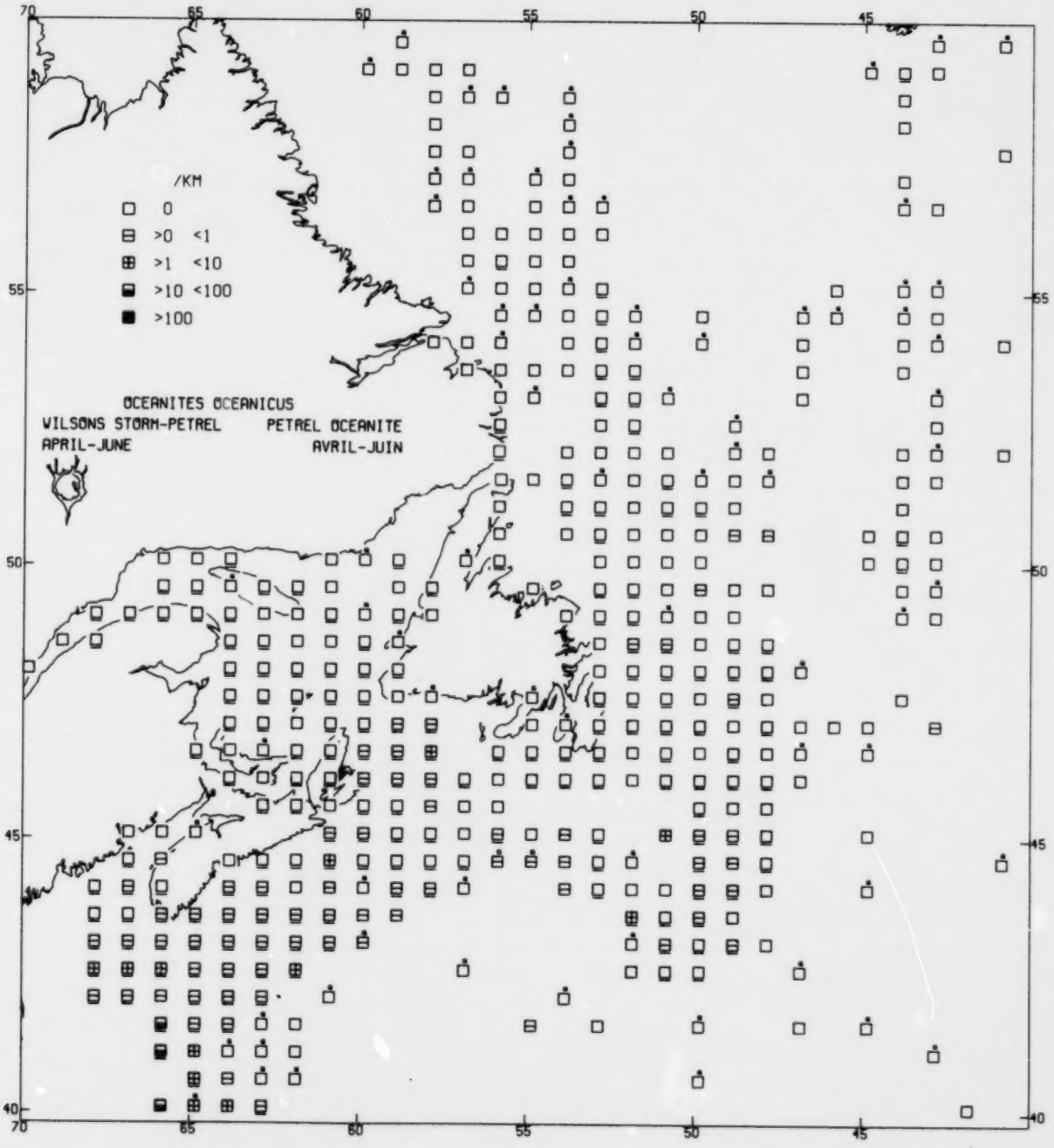
Map 5b
Atlantic, July–September



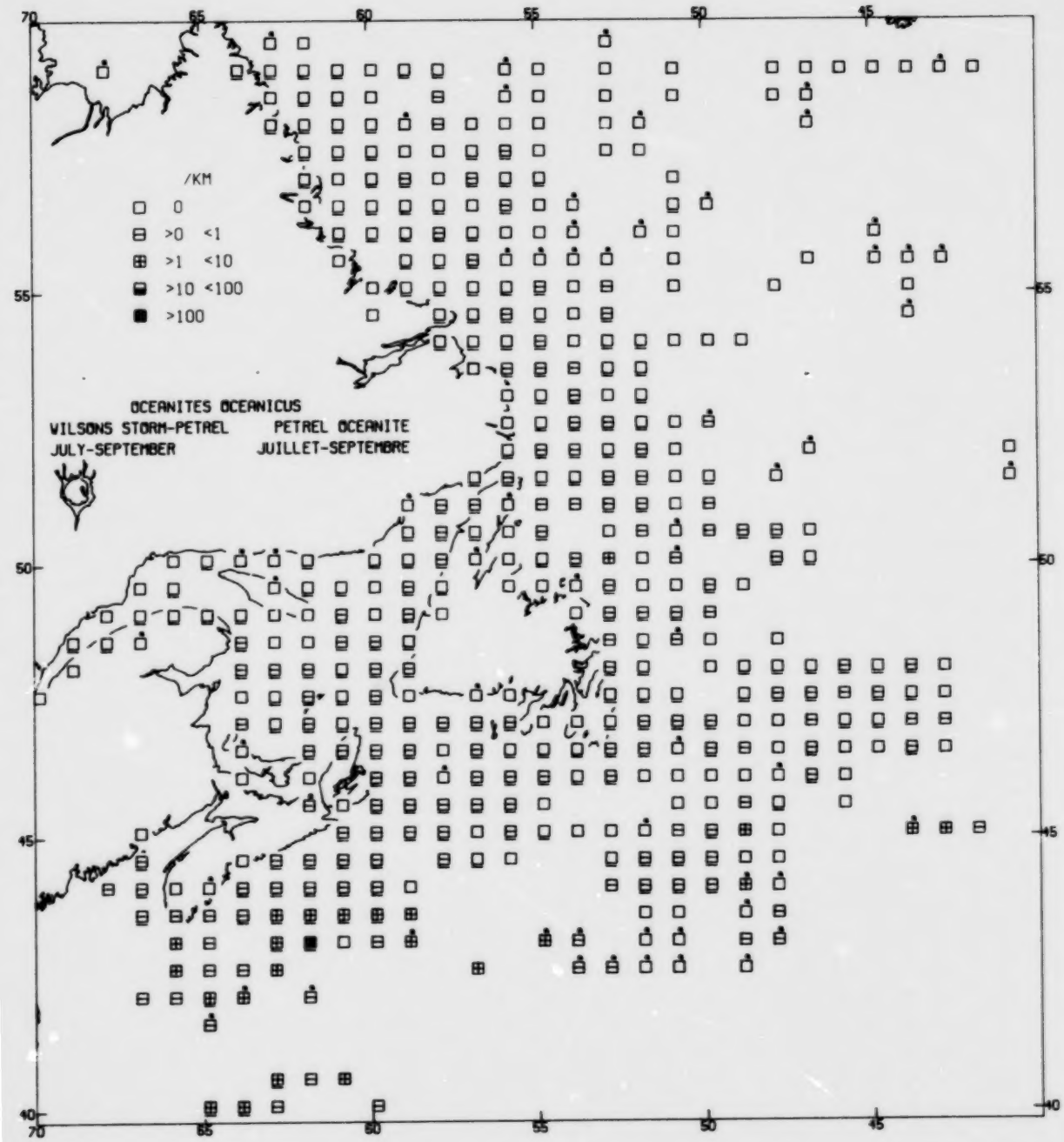
Maps 6a–b

Wilson's Storm-Petrel distributions

Map 6a
Atlantic, April–June



Map 6b
Atlantic, July–September



5.5. Northern Gannet (*Sula bassana*) (Maps 7a–c)

5.5.1. Breeding distribution (Map 7a)

The Northern Gannet is a North Atlantic species that breeds in Atlantic Canada (c. 31 000 pairs), Britain and Ireland (c. 142 000), the English Channel Islands (c. 3000), Brittany (c. 3800), Norway (c. 800), Faeroe (c. 2500), and Iceland (c. 21 000) (Nettleship 1976; Cramp and Simmons 1977; Nelson 1978*a*,*b*). The Canadian gannet population perhaps numbered 125 000 pairs before the onset of human persecution in the 19th century—most of them, as today, at colonies in the Gulf of St. Lawrence (Map 7a). The population has made a slow recovery, and two extinct colonies in the Bay of Fundy and another in the northeast Gulf of St. Lawrence have yet to be re-established (Brown *et al.* 1975*a*).

Adult gannets arrive at Bonaventure Island, the main Canadian colony, in mid-April, and subadults are in the vicinity of the site from May onwards. The adults lay in mid-May, and the young hatch in early July (Poulin 1968; Nelson 1978*a*,*b*). This timing is rather later than in British colonies (Nelson 1978*a*,*b*), and is presumably delayed by the persistence of ice in the Gulf of St. Lawrence until April (Anon. 1968). The young birds leave the colony in October, sometimes even later.

5.5.2. Pelagic distribution

(*a*) General

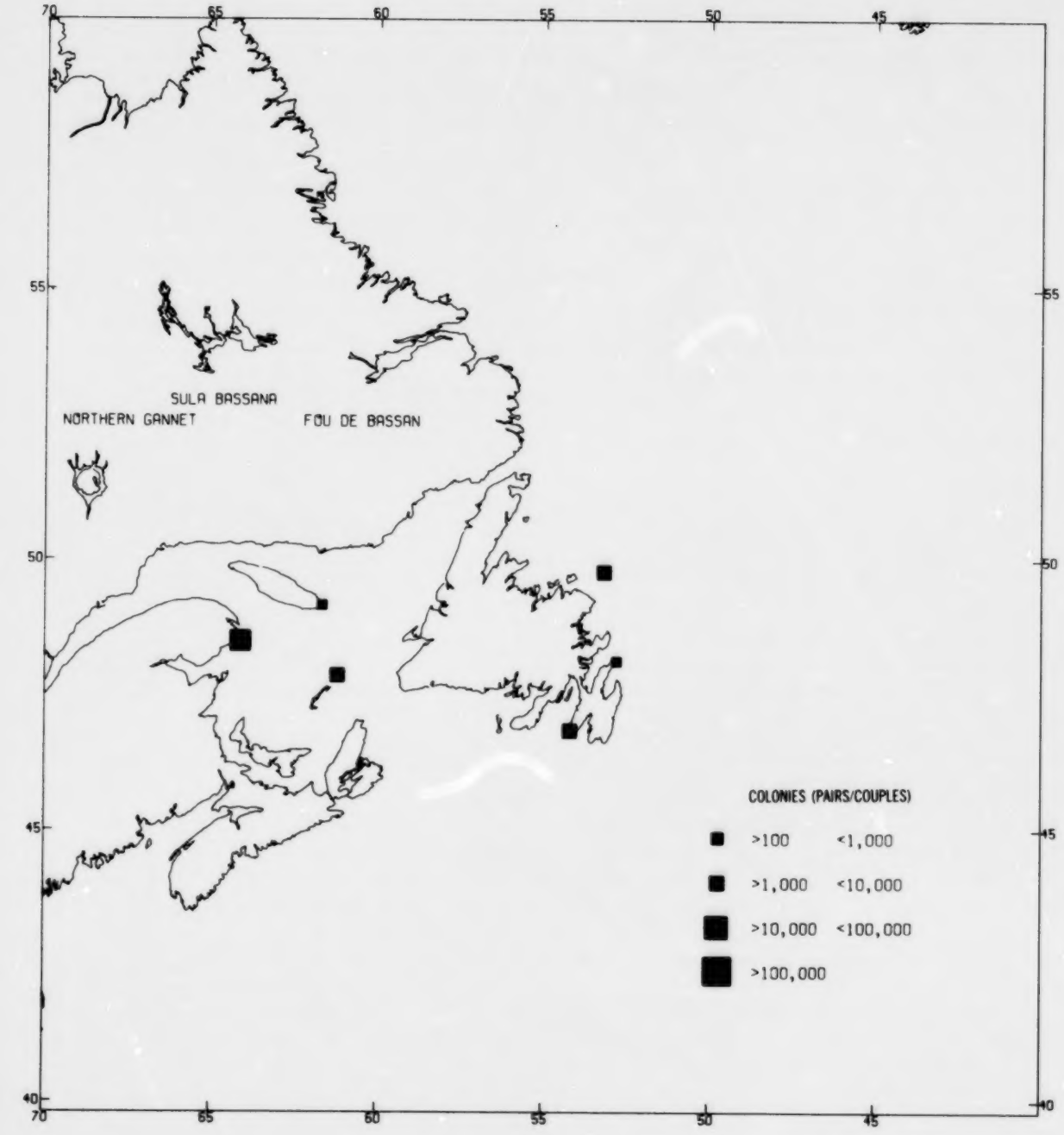
Gannets winter in the subtropics. Birds from British and Icelandic colonies migrate to northwest Africa. Canadian birds move to the southeast United States and the Gulf of Mexico. In both cases the juveniles and subadults travel farther and remain longer in winter quarters than do the adults (Palmer 1962; Cramp and Simmons 1977; Nelson 1978*a*,*b*; Brown 1979; Petersen 1982). In the western Atlantic the peak of the southbound migration passes Long Island, NY (c. 40°30′N) in late November, and the first birds reach Florida and the Gulf of Mexico in December. The return begins in March, with a peak of movement off New York in late March and early April, by which time almost all gannets have left the Gulf of Mexico (Palmer 1962).

(*b*) *Atlas* maps: Atlantic

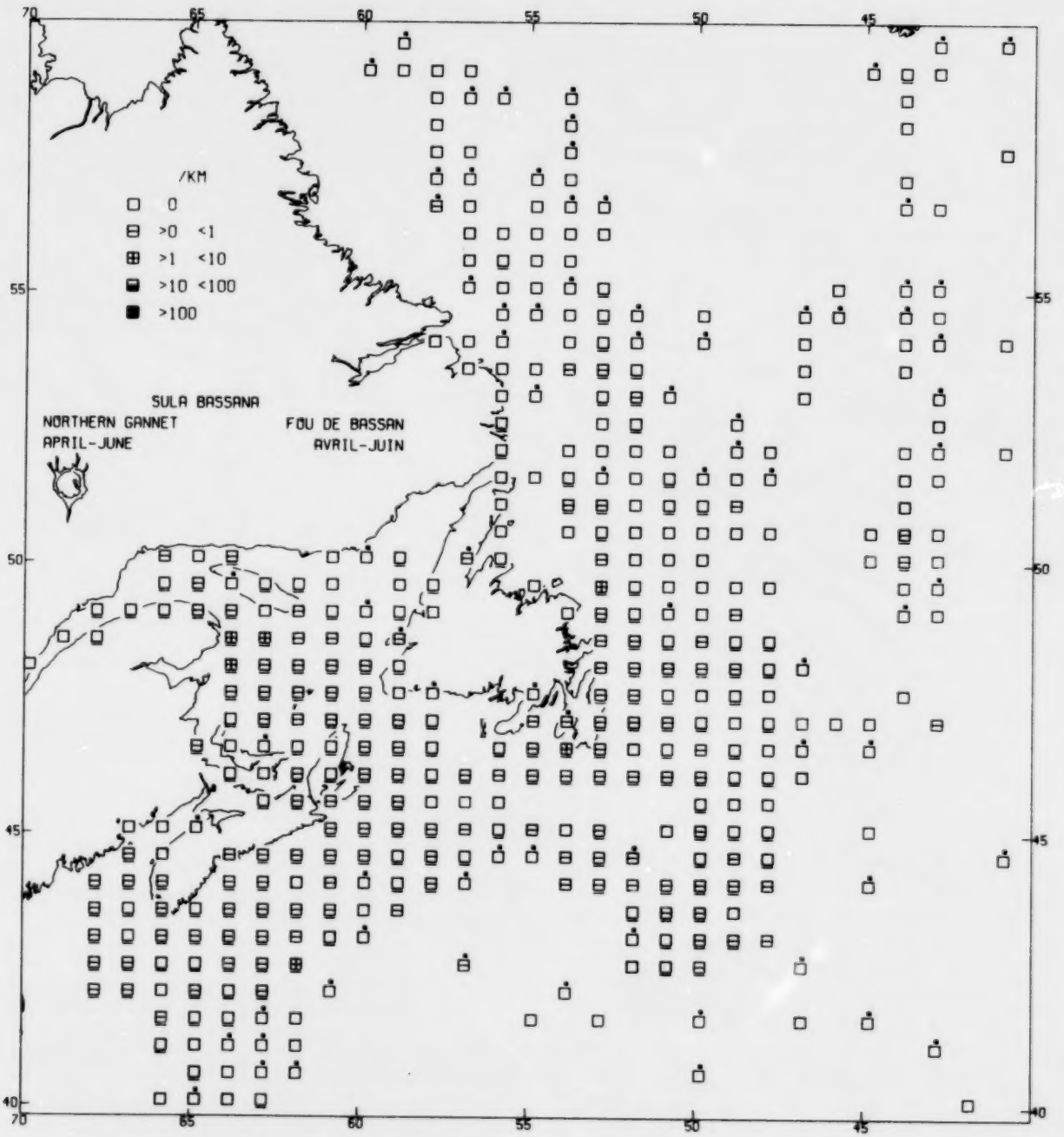
A concentration of adult birds winters at the shelf-break in the Mid-Atlantic Bight off New Jersey and New York, c. 39°–40°N, and there are scattered birds farther north, but the peak of spring movement over Georges Bank is in March–April (Powers 1983). A few birds remain on Georges Bank all summer. Meanwhile gannets are scattered but widespread over the Scotian Shelf in March and April. They enter the Gulf of St. Lawrence in May, after the ice has broken up. From June to August they are most common close to the colonies in the Gulf and Newfoundland, with some birds—presumably subadults—in the region of the extinct colonies in the Bay of Fundy. Birds also move up the Labrador coast in August and reach c. 63°N at the eastern entrance of Hudson Strait (Brown *et al.* 1975*a*). Occasional gannets are seen off west Greenland north to c. 69°N at this season (Salomonsen 1967), but a banding recovery shows that some at least of these are from Iceland, not Canada (Petersen 1982: Fig. 7). There appears to be a withdrawal from Labrador waters in September, and from northeast Newfoundland in October. The birds seen on the Scotian Shelf in October–December are on southbound migration; observations from the coast of Nova Scotia show that this is particularly heavy during the last half of October, the younger birds preceding the adults (NSBS 1971–84). They pass through New England waters in November–December (Powers 1983).

Map 7a–c
Northern Gannet distributions

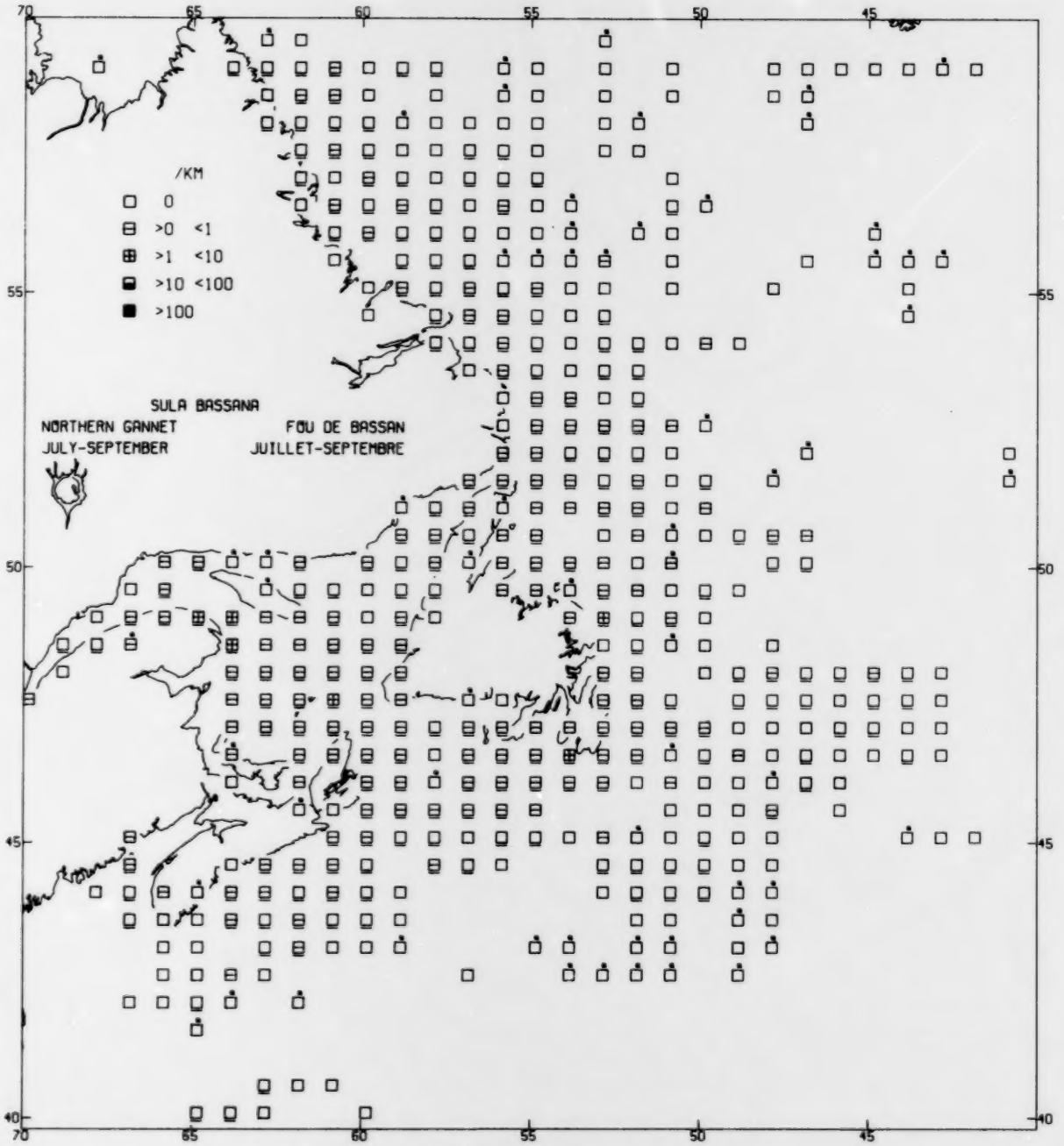
Map 7a
Atlantic colonies



Map 7b
Atlantic, April–June



Map 7c
Atlantic, July–September



5.6. Great Cormorant (*Phalacrocorax carbo*) Double-crested Cormorant (*Phalacrocorax auritus*)

Great Cormorants breed in North America in the Gulf of St. Lawrence, from southern Newfoundland to southern Nova Scotia, and in the Disko region of west Greenland (c. 70°N) (Salomonsen 1950, 1967; Palmer 1962; Lock and Ross 1973; Brown *et al.* 1975*a*). The Canadian population numbers c. 2500 pairs, breeding mainly in Cape Breton and the Gulf of St. Lawrence. It winters from Atlantic Canada south to New York, occasionally farther south. The Greenland population is apparently resident. The species also occurs through much of the Eastern Hemisphere (Palmer 1962, Cramp and Simmons 1977).

The Double-crested Cormorant is a North American species that breeds from the Gulf of St. Lawrence to Long Island, NY, and also in Florida, the Bahamas, the Great Lakes, the Prairies, and on the Pacific coast (Palmer 1962, Godfrey 1966, Lock and Ross 1973, Brown *et al.* 1975*a*). The eastern Canadian population numbers c. 27 000 pairs; its centre of distribution lies a little south of the Great Cormorant's. It winters along the Atlantic coast from New York south. The species is generally absent from Nova Scotia between November and March, although occasional birds overwinter (NSBS 1971–84).

Both cormorants stay close to land and are seen offshore only during migration. Their breeding ranges are therefore good indices of their pelagic distributions in summer.

5.7. Red-necked Phalarope (*Phalaropus lobatus*) Red Phalarope (*Phalaropus fulicarius*)

5.7.1. Breeding distributions

Phalaropes are shorebirds that nest on the tundra but winter at sea. Both species have circumpolar breeding distributions. Red Phalaropes are primarily High Arctic birds that breed in Svalbard, Novaya Zemlya, the north coasts of Siberia and Alaska, the Canadian Arctic Islands and northwest Hudson Bay, west and northeast Greenland, and Iceland. Red-necked Phalaropes are Low Arctic birds, breeding in Iceland, Faeroe, northern Scotland, northern Scandinavia, Siberia, Alaska, southwest and southeast Greenland and, in Canada, from southern Baffin Island south to James Bay and southern Labrador. (Salomonsen 1950, 1967; Fisher and Lockley 1954; Godfrey 1966; Cramp and Simmons 1983).

Red-necked Phalaropes reach west Greenland in the last half of May and lay early in June; the young hatch in July. Red Phalaropes do not arrive until mid-June. The adults of both species leave the breeding area by the end of July, and the juveniles in August (Salomonsen 1967, see also Cramp and Simmons 1983).

5.7.2. Pelagic distributions

Both phalaropes winter at sea in areas of upwelling and convergence: Red Phalaropes off west and southwest Africa and western South America, Red-necked Phalaropes off Peru, southern Arabia and in the southwest Pacific (Cramp and Simmons 1983).

Red-necked Phalaropes, both in the Nearctic and Palaearctic, migrate extensively overland. In the fall North American birds move southwest from the Arctic in late summer, cross the Prairies to California, and then go on down the Pacific coast to Peru; they return by the same route in the spring (Godfrey 1966, Cramp and Simmons 1983). They are rarely seen at sea in the *Atlas* survey area, though there are a few records from Davis Strait and the Labrador Sea in August–September (Brown *et al.* 1975*a*). Small numbers are seen in the southwest Bay of Fundy in spring (Orr *et al.* 1982) and large numbers—up to 2 million birds (Vickery 1978)—return there in August, presumably heading to and from the eastern Canadian Arctic and Greenland, and possibly also Iceland. This migration apparently takes place overland (Orr *et al.* 1982). The routes and destinations of these birds south of Fundy are unknown; the species is not known to winter anywhere in the Atlantic (Cramp and Simmons 1983), and it is scarce on Georges Bank and farther south (Powers 1983). It is possible that they reach Peru by way of the Caribbean and the Isthmus of Panama (Jehl 1974*b*).

Red Phalaropes are more oceanic, and spend the winter well offshore. Small numbers of phalaropes, probably of this species, winter in the Gulf of Mexico (Duncan and Havard 1980), but it is likely that most eastern North American birds cross the Atlantic to west Africa. Birds return to the Mid-Atlantic Bight (c. 35°N) in April, and reach Georges Bank (c. 41°30′N) in May (Brown *et al.* 1975*a*, Orr *et al.* 1982, Powers 1983). They apparently move north well offshore, along the shelf-break from the Mid-Atlantic Bight, via Georges Bank and the Scotian Shelf, and are clear of Atlantic Canadian waters by early June. They return to southeast Labrador and northeast Newfoundland in July. Red Phalaropes are regularly seen on the west side of Davis Strait, at the shelf-break east of Labrador, and out on the Grand Banks in August; in contrast to spring, they are scarce on Georges Bank in the fall. This distribution pattern suggests that the fall migration route continues southeast across the Atlantic to west and southwest Africa (Cramp and Simmons 1983). Few birds remain off Newfoundland or Labrador in September, though stragglers have been seen east of Flemish Cap as late as November (R.G.B. Brown, unpubl.). There are large flocks in the southwestern Bay of Fundy in August–September, but the numbers of Red Phalaropes there are much lower than those of Red-necked Phalaropes at this season (NSBS 1971–84, Brown 1980*a*).

5.8. Pomarine Jaeger (*Stercorarius pomarinus*)
Parasitic Jaeger (*Stercorarius parasiticus*)
Long-tailed Jaeger (*Stercorarius longicaudatus*)
Great Skua (*Catharacta skua*)
South Polar Skua (*Catharacta maccormicki*)

5.8.1. Breeding distributions

Jaegers are Arctic birds with circumpolar distributions. Pomarine Jaegers breed from the White Sea to eastern Siberia, in northern Alaska, in the Canadian Arctic, mainly on the islands south of Parry Channel, and possibly in the Disko Bugt area of west Greenland. Parasitic Jaegers have a similar distribution, but they also breed in Franz Josef Land, Svalbard, northern Scandinavia, Scotland, Faeroe, Iceland, and on both coasts of Greenland; they breed in Arctic Canada between Jones Sound and southern Hudson Bay. The Long-tailed Jaeger is a circumpolar, High Arctic species which breeds in the *Atlas* area south to Hudson Strait, and to c. 70°N in west Greenland. (Salomonsen 1950, 1967; Fisher and Lockley 1954; Godfrey 1966; Cramp and Simmons 1983).

In the North Atlantic the Great Skua breeds only in Scotland, Faeroe, and Iceland. Most of the skua populations in the Antarctic are usually classified as subspecies of *C. skua*, though the South Polar Skua *C. maccormicki*, which breeds on the coasts of Antarctica, is a separate species (Fisher and Lockley 1954, Watson 1975, Cramp and Simmons 1983).

The only reasonably complete population estimates for any of these species are for the North Atlantic population of the Great Skua: c. 6000 pairs in Iceland, c. 500 in Faeroe, and c. 6000 in Scotland (Cramp and Simmons 1983).

Parasitic Jaegers reach their breeding grounds in west Greenland in May, though not until June farther north; Long-tailed Jaegers arrive a little later; both species leave their breeding areas by the end of August (Salomonsen 1967). In Scotland, Great Skuas return to their colonies in April and lay in the middle of May; the young fledge in July and August, and the fall migration begins in September.

5.8.2. Pelagic distributions

The three jaegers winter in the tropics and in the Southern Hemisphere. In the Atlantic, all three move down the west coast of Africa as far as South Africa. Parasitic and Long-tailed Jaegers also move down the east coast of South America to the Patagonian Shelf, but the majority of Pomarines move no farther south than the Caribbean (Fisher and Lockley 1954, Cramp and Simmons 1983).

Pomarine Jaegers are the earliest to arrive off eastern North America in the spring (Brown *et al.* 1975*a*, Powers 1983). The first birds reach 40°N in April; they are regularly seen in small numbers on the Scotian and Labrador Shelves and the northern Grand Banks in May, but only a few stragglers remain off Atlantic Canada in June–July. Pomarines are common in Davis Strait in August, and the birds have returned to the Labrador Shelf by then; however, very few remain in the *Atlas* area in October. Parasitic and Long-tailed Jaegers do not arrive until May, but they show a similar distribution pattern in their northward migration; Parasitics, like Pomarines, move south again in September, but the main fall migration of Long-tailed Jaegers takes place in August. Both Pomarine and Parasitic Jaegers occur in small numbers on Georges Bank in May–November, but Long-tailed are rare there (Powers 1983).

Banding shows that Great Skuas from both Scotland and Iceland occur off Greenland and eastern Canada, with Icelandic birds probably in the majority (Thomson 1966, Salomonsen 1971*b*, Tuck 1971, Furness 1978, Cramp and Simmons 1983). The Scottish birds are mainly in their 2nd and 3rd years; younger and older Skuas apparently remain in the eastern Atlantic. Skuas occur in small numbers all year round on Georges and the Grand Banks and Scotian Shelf; they are also regularly seen on the Greenland side of Davis Strait, north to c. 70°N, in August–October (Salomonsen 1967, Brown 1968, Brown *et al.* 1975*a*, Powers 1983).

The majority of the Skuas seen in the *Atlas* survey area are large, dark, heavy-billed birds, undoubtedly *C. skua* (Cramp and Simmons 1983). However the smaller, paler, thinner-billed *C. maccormicki* has recently been collected off New England and farther south, in west Greenland, and on Flemish Cap east of the Grand Banks (e.g. Salomonsen 1976, Lee and Booth 1979, Jensen 1982). It is difficult to separate the two species in the field, and so it is not possible to say how regularly the South Polar Skua occurs in the North Atlantic.

5.9. Herring Gull (*Larus argentatus*)
(Maps 8a–d)
Lesser Black-backed Gull (*Larus fuscus*)
Iceland Gull (*Larus glaucoides glaucoides*)
Kumlien's Gull (*Larus glaucoides kumlieni*)
Thayer's Gull (*Larus thayeri*)
Great Black-backed Gull (*Larus marinus*)
(Maps 9a–d)
Glaucous Gull (*Larus hyperboreus*)

5.9.1. Breeding distributions

The Herring Gull is a member of a complex chain of closely related species and subspecies whose distributions cover most of the Nearctic and Palaearctic regions (Fisher and Lockley 1954). *Larus argentatus smithsonianus* is the form that occurs in most of North America, breeding from Virginia north to southern Baffin Island, in the Great Lakes, and across much of the interior of Canada east of the Rockies. The Iceland Gull replaces the Herring Gull in west and southeast Greenland. Kumlien's and Thayer's Gulls replace and partially overlap with the Herring Gull in, respectively, Hudson Strait and the North American High Arctic. The Lesser Black-backed Gull is a European member of the group that breeds as far west as Iceland, and regularly strays into eastern North American waters.

The Great Black-backed Gull is a larger species, related to but not part of the chain. It occurs only in the North Atlantic, breeding from North Carolina north to Hudson Strait, and with a small population in the Great Lakes, in west and southeast Greenland, Iceland, southern Svalbard, and northern Europe from

Brittany to southern Novaya Zemlya. The Glaucous Gull replaces the Great Black-back in the Arctic. It has a circumpolar distribution which, in the western Atlantic, includes the whole of Greenland and the eastern Canadian Arctic south to central Labrador (Salomonsen 1950, 1967; Fisher and Lockley 1954; Godfrey 1966; Smith 1966; Brown *et al.* 1975*a*; Duncan 1981; Cramp and Simmons 1983).

The numbers of these gulls breeding in the *Atlas* survey area are not known, nor is there even a complete register of their breeding sites. However, partial censuses of Herring Gulls and Great Black-backs in New England and Atlantic Canada show that at least 125 000 and 30 000 pairs, respectively, breed there (Lock 1973, Drury 1973–74). Drury has shown that the New England populations of both species have increased dramatically since 1900, initially through relaxation of human persecution but, more recently, because of the birds' exploitation of human garbage. The Iceland Gull population in west Greenland is large enough for the species to be a popular game bird, but no estimate of their numbers is available (Salomonsen 1967).

In Atlantic Canada, both Herring Gulls and Great Black-backs begin to lay their clutches of 2–3 eggs from mid-April to mid-May, but laying continues into early June; the chicks hatch after about a month, and the first ones fledge in the last half of July (Bent 1921, Peters and Burleigh 1951, Tufts 1961). In Greenland, Iceland Gulls lay from mid-May to mid-June, and the young fledge in late July and early August. The timing of the Glaucous Gull cycle is a little later, especially in the High Arctic (Salomonsen 1967).

5.9.2. Pelagic distributions

(*a*) General

These gulls are commonest close to land or, in the Arctic, to ice edges, though they occur regularly farther offshore outside the breeding season. Banding shows that the general trend of dispersal of Herring Gulls from colonies in the Bay of Fundy is southwestwards, to New England and beyond (e.g. Gross 1940), though this in part reflects the greater chances of recovery along the coast than out at sea. The true picture is undoubtedly complex. Herring Gulls and Great Blackbacks, stained by oil chemically identical to that released by *Argo Merchant* off New England in December 1976, were collected in January 1977 near Sable Island, NS, c. 850 km to the *northeast* (E.M. Levy, Bedford Institute of Oceanography, pers. commun.; see also Powers and Rumage 1978). Longer migrations occur. A Great Black-back banded on the Murmansk coast has been recovered in east Greenland, and one from Iceland in southwest Greenland (Salomonsen 1967). The west Greenland population remains in the country, wintering along the southwest coast (Salomonsen 1967).

Iceland, Kumlien's, and Glaucous Gulls all move south to some extent during the winter. Many Iceland Gulls winter in Greenland, but some leave the country; there have been five recoveries of banded birds in winter from Iceland and further east in the Atlantic, and one from Newfoundland (Salomonsen 1967). Kumlien's Gull is the subspecies of *L. glaucoides* that is usually seen in winter in Atlantic Canada, south to southern Nova Scotia and Georges Bank (NSBS 1971–84, Powers 1983). Glaucous Gulls have a similar winter range. Banding has shown that Glaucous Gulls from Svalbard move southwest in winter, and one has been recovered in southwest Greenland (Salomonsen 1967). Thayer's Gull winters on the Pacific coast (Godfrey 1966), but the species has been collected in Atlantic Canada (Peters and Burleigh 1951).

(*b*) *Atlas* maps: Atlantic

Herring Gulls are most common off New England in October–May, with a peak in numbers in March; the species occurs as far south as c. 35°N. They move inshore during the summer (Powers 1983). The *Atlas* maps show that in January–March Herring Gulls are scarce offshore, but commonest on the Scotian Shelf, and along the coast of Nova Scotia and Newfoundland; they do not go far out onto the Grand Banks, and their northern limit seems to be c. 50°N. Distribution in April is similar but the birds are more common, presumably as migrants return from the south. When the pack-ice melts in May, Herring Gulls move into the Gulf of St. Lawrence and up the Labrador coast at least as far as 56°N; the latter birds are probably en route to colonies in Hudson Bay and southern Baffin Island. Herring Gulls move inshore in June, and the lack of inshore coverage has undoubtedly led to underestimates of their abundance in the *Atlas* maps. Their southern limit is c. 40°N at this time. They begin to move offshore onto the Scotian Shelf again in July, and there are birds along the whole of the inshore portion of the Labrador Shelf in August. The centre of Herring Gull distribution offshore in October is off southeast Labrador and northeast Newfoundland; their northern limit has receded to c. 56°N by then. They are commonest on the Scotian Shelf in November–December, and their northern limit is once again c. 50°N, as it was in the spring. There is a second peak in New England waters in October–December.

The distribution of Great Black-backed Gulls off Atlantic Canada is broadly similar to that of Herring Gulls though the birds tend to occur farther offshore. As their breeding distribution implies (see above), they also occur farther north. They are regularly seen close to the Greenland coast in August–September, up to c. 69°N, with stragglers to c. 75°N (Brown *et al.* 1975*a*). The Great Black-backs off southern Greenland in January–March are presumably either wintering birds from west Greenland or migrants from Iceland (see above, and Brown 1968)

Iceland/Kumlien's Gulls are commonest in January–March in Cabot Strait and in the eastern Gulf of St. Lawrence, and to a lesser extent off southeast Newfoundland, southwest Nova Scotia, and on Georges Bank (Brown *et al.* 1975*a*, Powers 1983). By May most of the birds are off southeast Labrador, and the southern edge of their range is c. 50°N. They are virtually absent from Atlantic Canada for the rest of the summer, but are regularly seen in August–September along the Greenland coast north to c. 70°N, along the southeast coast of Baffin Island, and in the eastern part of Hudson Strait. They return to eastern Newfoundland in October, and to southern Nova Scotia and Georges Bank in November–December.

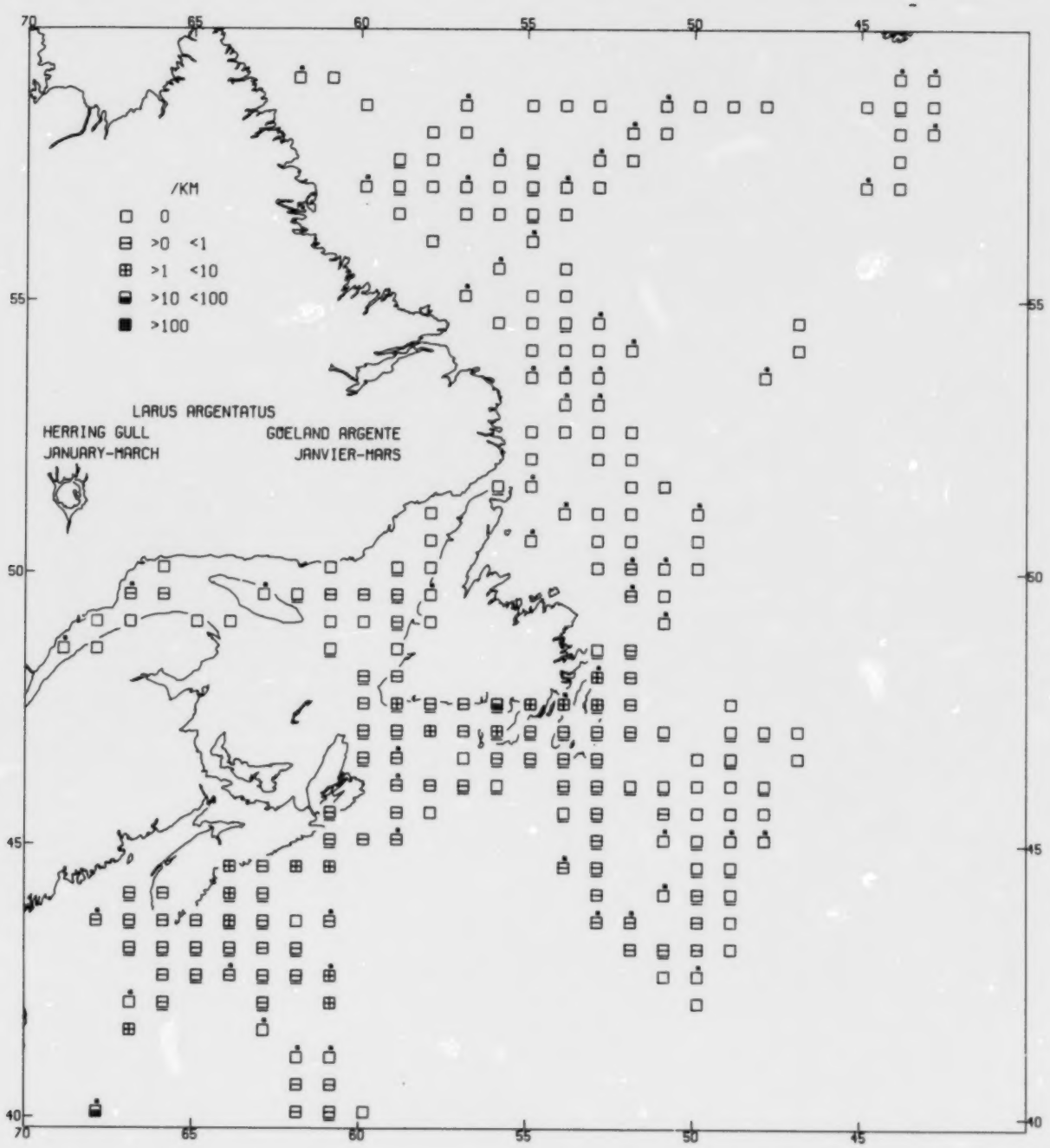
The migrations of Glaucous Gulls to and from Atlantic Canadian waters are similar to those of Iceland/Kumlien's Gulls (Brown *et al.* 1975*a*). They are common in August–September in the Arctic north of c. 65°N, but by October most of the birds are concentrated in Davis Strait, and the vanguard of their migration has reached c. 54°N off Labrador. Small numbers occur on Georges Bank in December–April (Powers 1983).

The only records of Thayer's Gulls in the *Atlas* files are in northern Baffin Bay and adjacent Sounds in August–September.

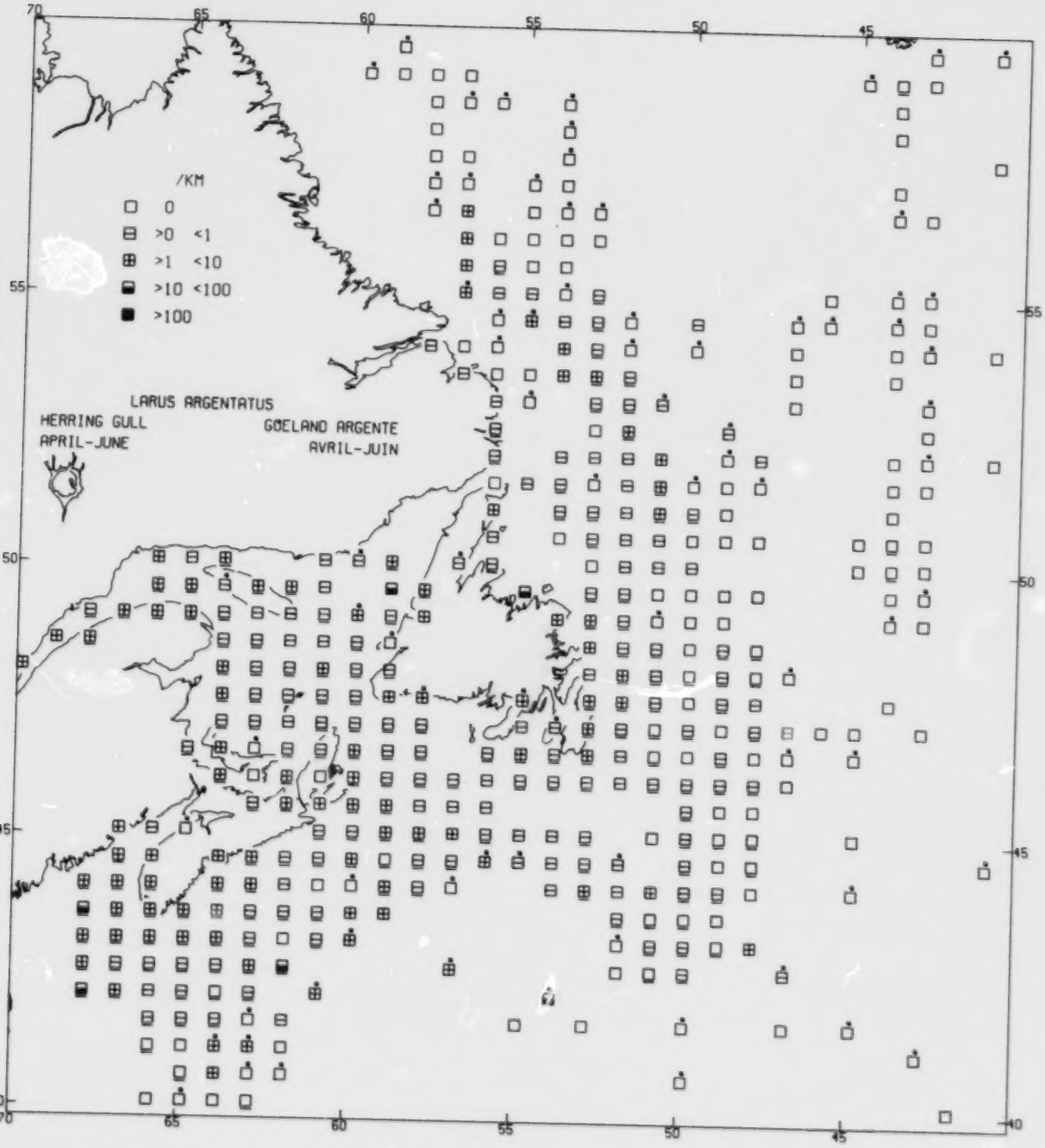
Maps 8a–d

Herring Gull distributions

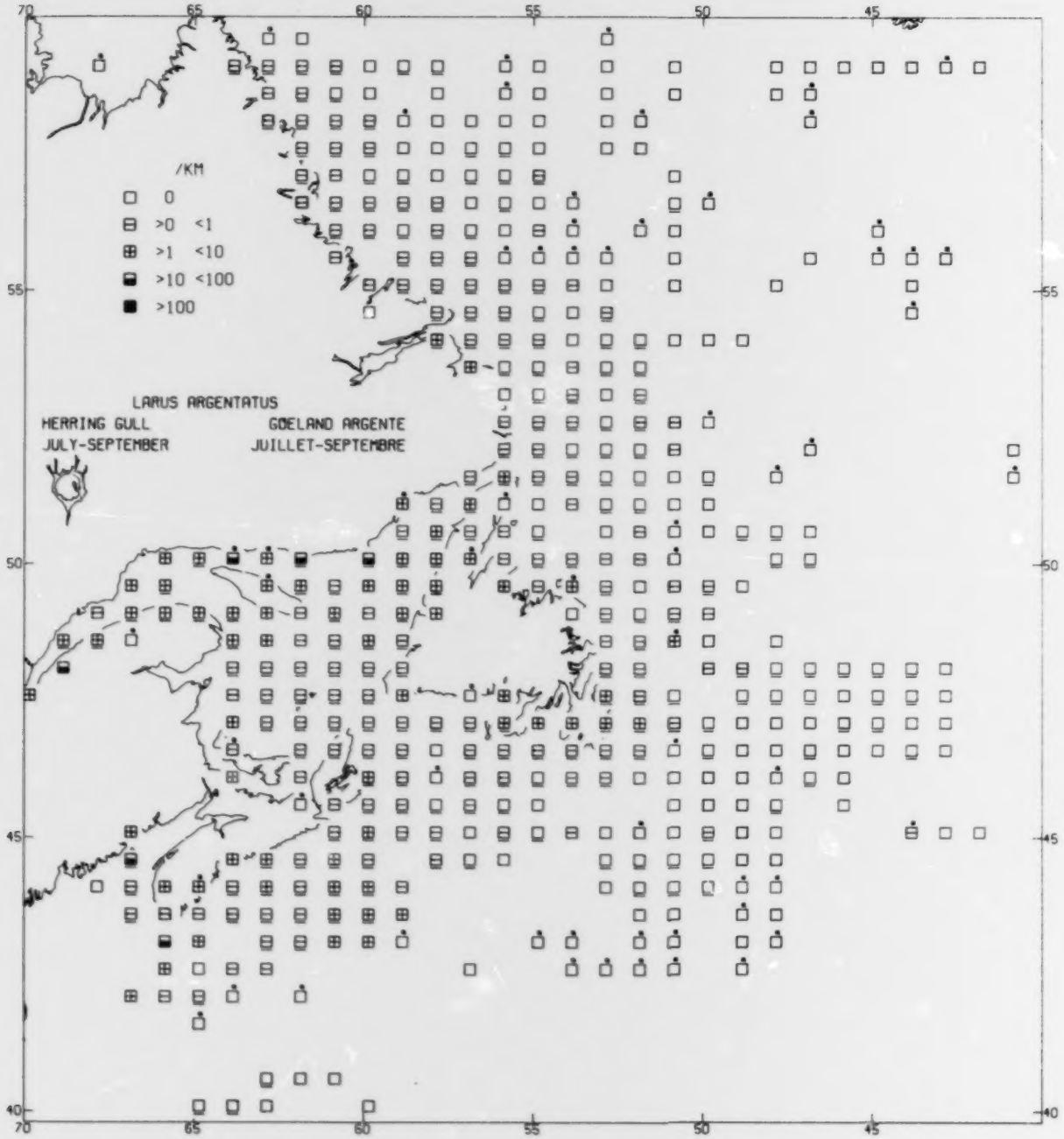
Map 8a
Atlantic, January–March



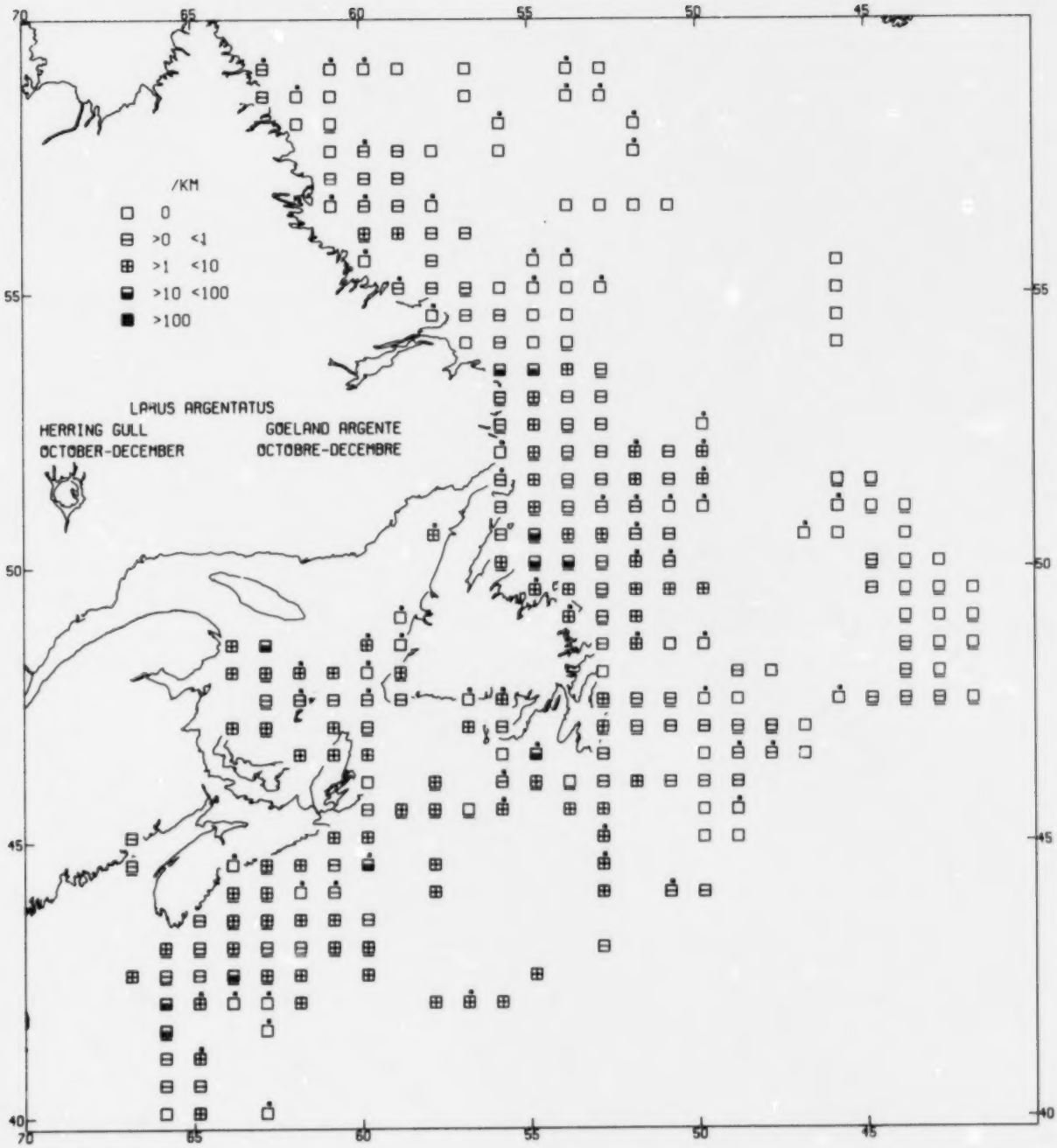
Map 8b
Atlantic, April–June



Map 8c
Atlantic, July–September



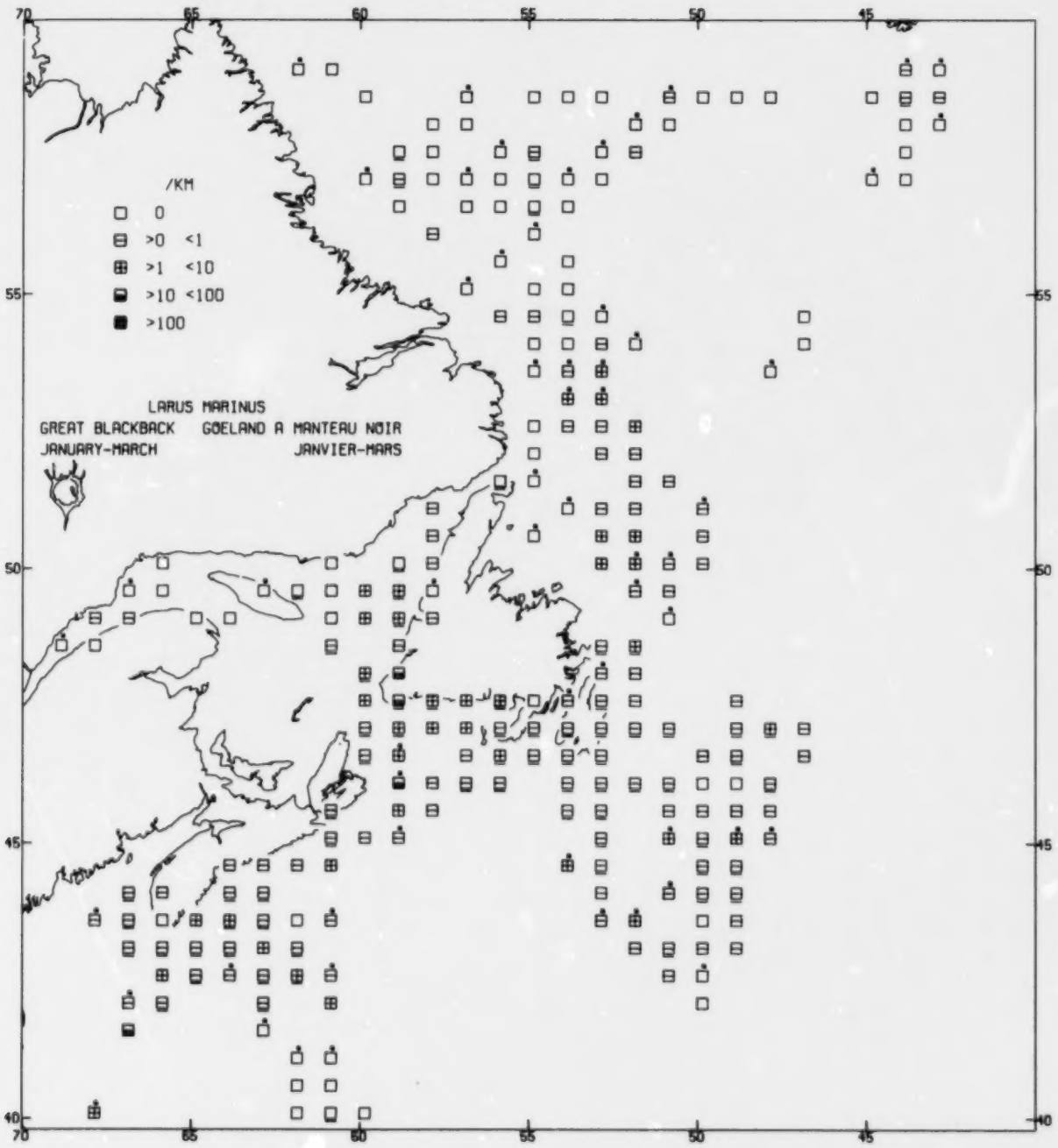
Map 8d
Atlantic, October–December



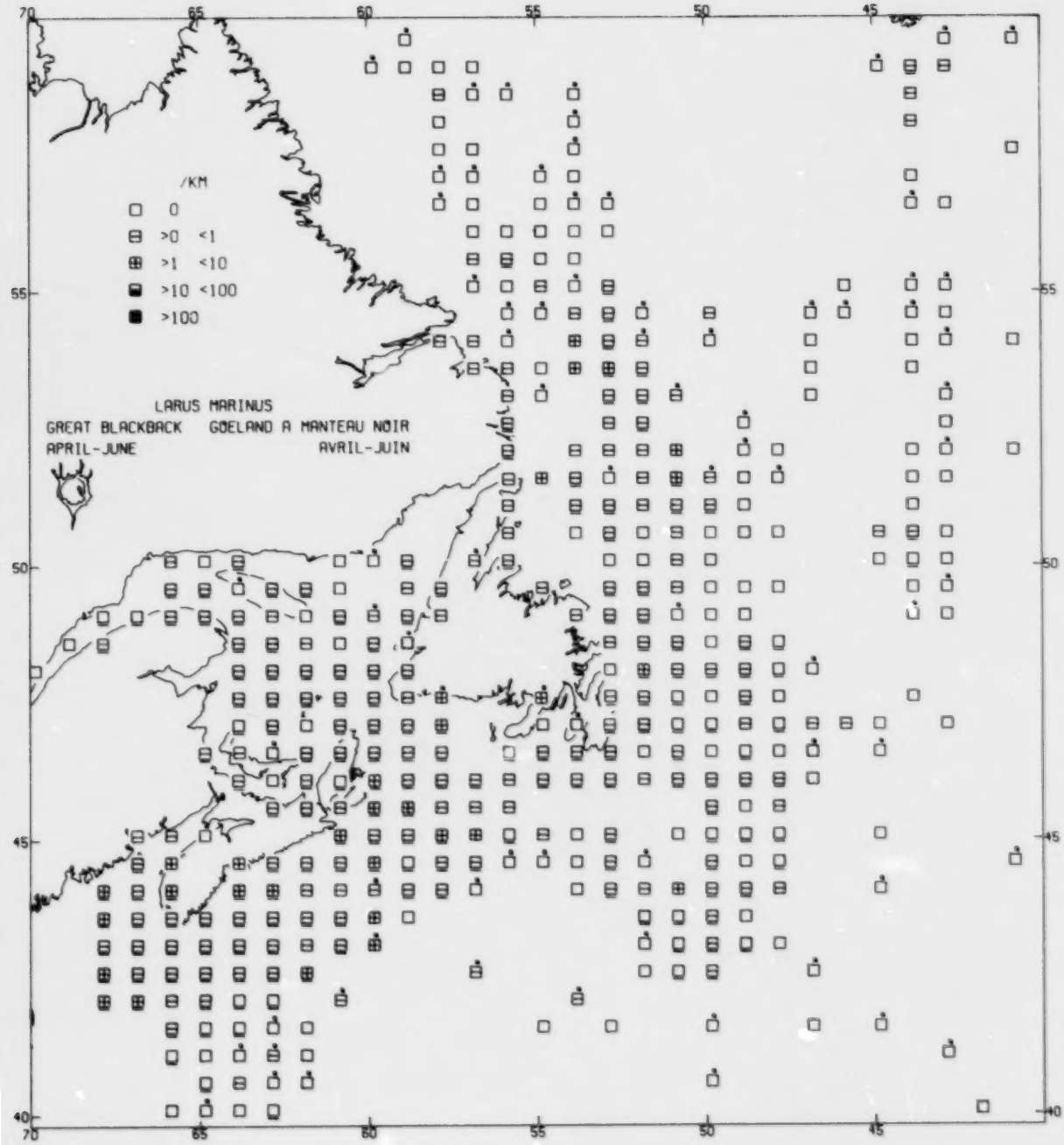
Maps 9a–d

Great Black-backed Gull distributions

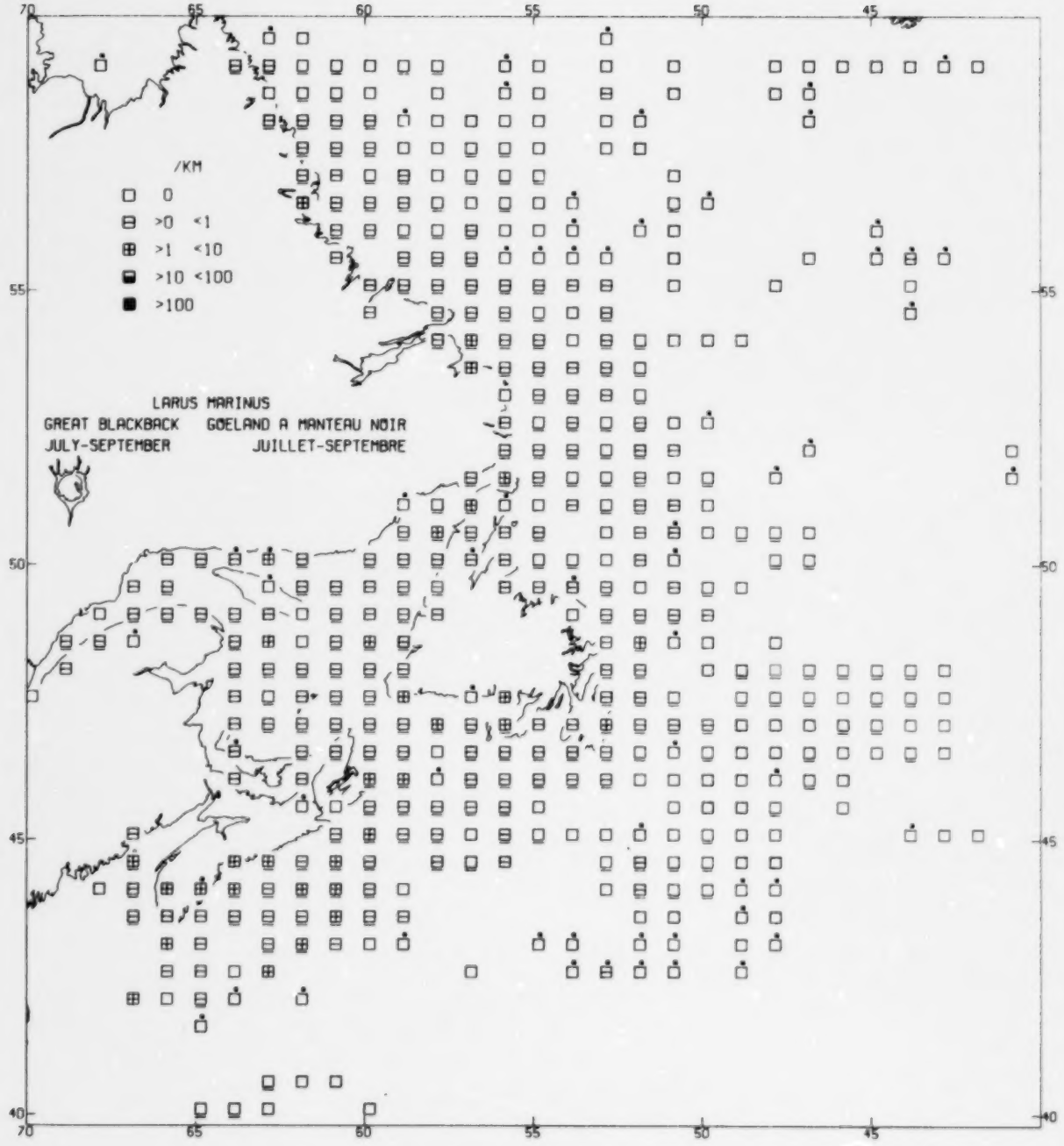
Map 9a
Atlantic, January–March



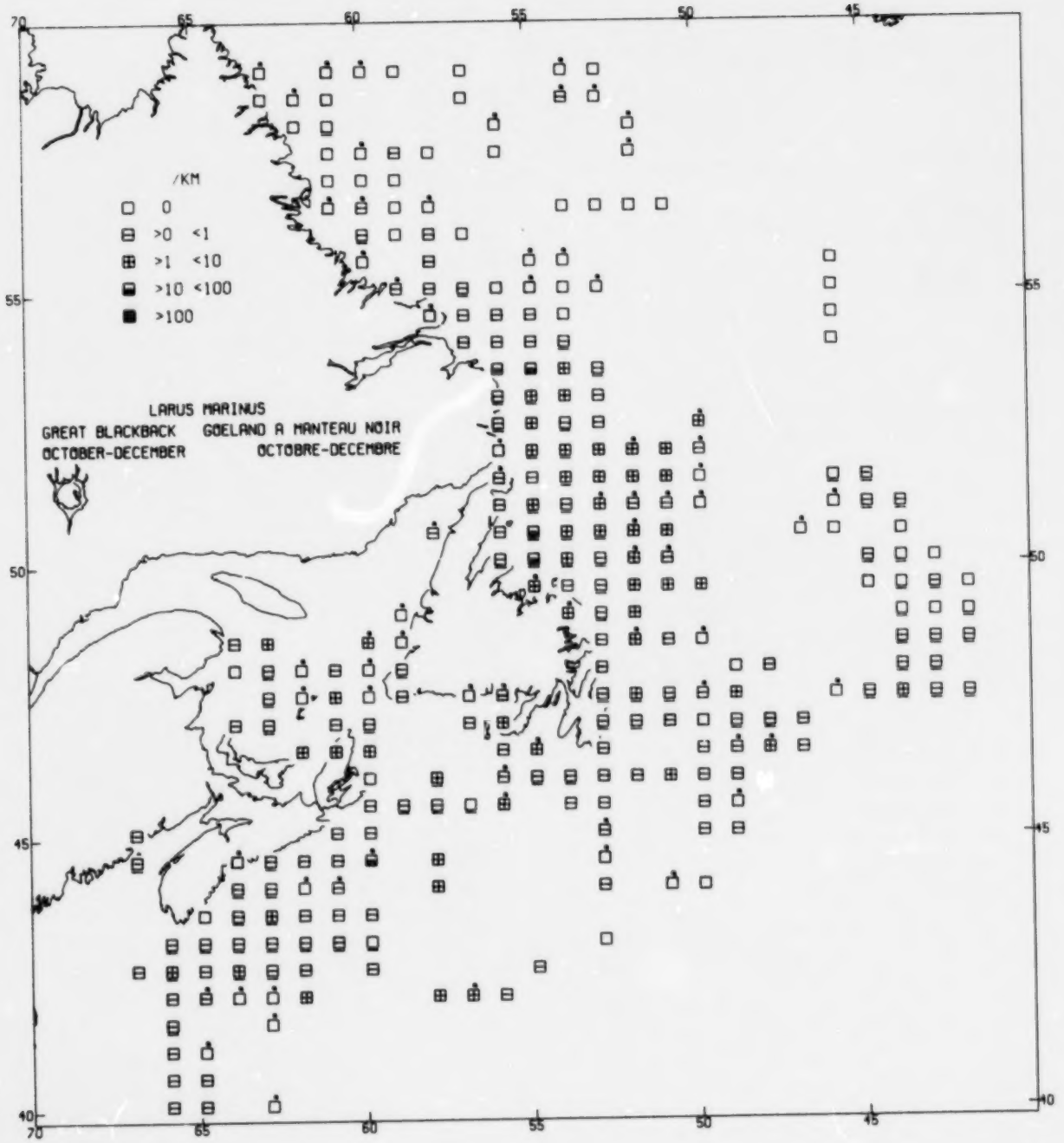
Map 9b
Atlantic, April–June



Map 9c
Atlantic, July–September



Map 9d
Atlantic, October–December



5.10. Ring-billed Gull (*Larus delawarensis*)

Ring-billed Gulls breed on lakes and rivers in the interior of North America from the Great Lakes west to Alberta and northeast California; small populations also breed in Newfoundland, Labrador, and northeastern New Brunswick (Peters and Burleigh 1951, Fisher and Lockley 1954, Godfrey 1966, Lock 1983). The species apparently abandons Newfoundland in the winter, possibly moving to Nova Scotia where Ring-billed Gulls are found in small numbers all winter (NSBS 1971–84). It is only occasionally seen offshore (Brown *et al.* 1975*a*).

5.11. Black-headed Gull (*Larus ridibundus*) Bonaparte's Gull (*Larus philadelphia*) Laughing Gull (*Larus atricilla*)

Black-headed and Bonaparte's Gulls are the two species of "hooded" gulls most often seen in Atlantic Canada. Neither is seen far from shore. The Black-headed Gull formerly bred only in the northern Palaearctic west to the British Isles. It colonized Iceland at the beginning of the century, reached southwest Greenland in the 1930s, and was first proved to breed there in 1969. The species reached eastern North America c. 1931 and now regularly occurs in winter from Atlantic Canada south to Delaware (c. 37°N), though breeding was not proved until 1977 (southwest Newfoundland) and 1982 (Magdalen Islands, Gulf of St. Lawrence) (Fisher and Lockley 1954, Erskine 1963, Vickery 1977, Salomonsen 1979*b*, Cramp and Simmons 1983, Aubry 1984.) Birds banded in Iceland have been recovered in Greenland and Newfoundland (Salomonsen 1971*b*, 1979*b*; Tuck 1971).

Bonaparte's Gull breeds on lakes in the coniferous zone of northwestern North America, from Alaska to western Hudson Bay, and winters on the Pacific coast, in the Great Lakes, and along the Atlantic coast from Massachusetts southwards (Fisher and Lockley 1954, Godfrey 1966, Cramp and Simmons 1983). Large numbers pass through the Passamaquoddy region of southwest New Brunswick from August to October, feeding on surface-swarms of euphausiids there (e.g. Braune and Gaskin 1982). There is surprisingly little overlap with the Black-headed Gull, which is largely confined to the Atlantic shore of Nova Scotia in the Canadian Maritimes, and is rarely seen in the Bay of Fundy (NSBS 1971–84).

Laughing Gulls breed on the Atlantic coast of North America from New England southwards, and a few may still breed in southern Nova Scotia and New Brunswick (Godfrey 1966, Drury 1973–74). They are coastal birds rarely seen north of 40°N (Powers 1983). They occur regularly in small numbers in Atlantic Canada, especially after hurricanes (Tuck 1968, Mills 1969, Brown *et al.* 1975*a*), and they have also reached west Greenland (Salomonsen 1967).

5.12. Ivory Gull (*Pagophila eburnea*) Sabine's Gull (*Xema sabini*) Ross' Gull (*Rhodostethia rosea*)

The Ivory Gull breeds in small colonies in Severnaya Zemlya, Franz Josef Land, Svalbard, northeast and northwest Greenland, the Canadian High Arctic islands, and northwest Baffin Island, and probably also in Novaya Zemlya (Blomqvist and Elander 1981, Reed and Dupuis 1983). It is a High Arctic species seldom seen far from pack-ice (e.g. Salomonsen 1950, 1967; Brown *et al.* 1974; Orr and Parsons 1982). The southern limit of its pelagic range, even in winter, is in the ice off northeast Newfoundland, though vagrants have occurred in New Brunswick and Nova Scotia (Godfrey 1966). Occasional Ivory Gulls remain off Labrador in summer (Brown 1976), but the birds are normally seen no farther south than the extreme north of Baffin Bay in the *Atlas* survey area. They move down to c. 72°N in Baffin Bay in September and to c. 69°N in October, with the advance of the pack-ice, though they are also abundant at glacier fronts in the Canadian High Arctic at this time (Brown *et al.* 1975*a*; Renaud and McLaren 1982, unpubl. CWS *Atlas* files). Banding has shown that Ivory Gulls wintering off Labrador come from east and west Greenland, and Franz Josef Land (Blomqvist and Elander 1981: Fig. 3).

Sabine's Gulls breed mainly on the coastal tundra in the Low Arctic and southern High Arctic zones: in northeast Siberia, Alaska, Canada from Ellesmere south to Southampton Islands, northwest and northeast Greenland, and Svalbard (Blomqvist and Elander 1981). They winter off Peru and Namibia. The birds apparently travel directly between Baffin Bay and the Bay of Biscay on their spring and fall migrations, and are only occasionally seen in Atlantic Canada south of Labrador (Mason 1951, Lambert 1973, Brown *et al.* 1975*a*, Powers 1983). Lambert suggested that the birds that appear in the Bay of Fundy in the fall have migrated south overland, via Hudson Bay and the Great Lakes.

Ross' Gull breeds mainly in the Kolyma region of northeast Siberia, but it has also bred in Svalbard and north and west Greenland, and two small colonies have recently been discovered in Canada in the High Arctic and western Hudson Bay (MacDonald 1979, Chartier and Cooke 1980, Blomqvist and Elander 1981). It migrates east into the Beaufort Sea in the fall, past the north coast of Alaska, and winters in the pack-ice of the Arctic Ocean; it has also been recorded on both sides of Davis Strait and, on one occasion, in Massachusetts (Blomqvist and Elander 1981).

5.13. Black-legged Kittiwake (*Rissa tridactyla*) (Maps 10a–h)

5.13.1. Breeding distribution

The Black-legged Kittiwake is a fairly small pelagic gull that breeds in the North Atlantic, North Pacific, and adjacent parts of the Arctic. The North Atlantic population is of the order of 4 million pairs. It breeds in Atlantic Canada, mainly in eastern Newfoundland and the Gulf of St. Lawrence (c. 99 000 pairs), the eastern Canadian Arctic (c. 110 000), west Greenland (>17 000), Iceland (order 100 000), Britain and Ireland (c. 470 000), Norway (c. 510 000), the Murmansk Coast (c. 45 000), Novaya Zemlya (>14 000), Svalbard (order 2 million); there are also populations of unknown size in Franz Josef Land, Jan Mayen, east Greenland, and Faeroe (Salomonsen 1950, 1967; Fisher and Lockley 1954; Joensen 1966; Joensen and Preuss 1972; Cramp *et al.* 1974; Brown *et al.* 1975*a*; Norderhaug *et al.* 1977; Petersen 1982; Cramp and Simmons 1983). The colonies in Atlantic Canada, the eastern Canadian Arctic, and west Greenland are shown in Maps 10a and f.

Kittiwakes nest on small ledges on steep cliffs. They return to their colonies in west Greenland in April (late March in open-water areas) and lay a clutch, usually of two eggs, in mid-June. The young hatch in mid-July and fledge in August, and the colonies are abandoned by the end of that month (Salomonsen 1950, 1967). Newfoundland birds return in March and lay at the beginning of June (Maunder and Threlfall 1972).

5.13.2. Pelagic distribution

(*a*) General

In the western North Atlantic, kittiwakes winter from Newfoundland waters south to Georges Bank, with stragglers as far south as c. 37°N (Brown *et al.* 1975*a*, Powers 1983). Banding returns show that these birds come from colonies in west Greenland, Iceland, Faeroe, Britain, Norway, Denmark, and the Murmansk coast (Salomonsen 1967, 1971*b*; Tuck 1971). The west Greenland birds are juveniles and arrive off Newfoundland in mid-November, sometimes earlier. Banding shows that these juveniles apparently spend their first summer well to the south of their colonies; a few of the summer recoveries of 2 to 3-year-old birds, and all those 4 years old or more, are from the Greenland breeding areas. Recoveries from France, Britain, and the North Sea show that a part of the Greenland population, including adults and subadults as well as juveniles, also winters in the eastern Atlantic. Subadults and juveniles from eastern Atlantic colonies occur off Newfoundland from mid-October onwards, and off west Greenland from June–October.

(*b*) *Atlas* maps: Atlantic

Kittiwakes are most common off New England in January–March, preferring the cooler waters north and east of Georges Bank (Powers 1983). However, the majority of birds seem to be on the Grand Banks and well offshore off northeast Newfoundland and southeast Labrador at this season. There are also birds in the deep waters between Newfoundland and Greenland from January to April, probably early migrants returning to Greenland. In May kittiwakes are commonest close to their colonies in eastern Newfoundland and the Gulf of St. Lawrence. Few birds are left on Georges Bank, the Scotian Shelf, and the southern Grand Bank, though they are still quite common off southeast Labrador; the latter are mainly juveniles (e.g. Brown 1968). Kittiwakes remain common close to their colonies in June and July. They appear to abandon southeast Labrador at the start of this period, but return later and occur all along the Labrador Shelf in August–September. The concentration off northeast Newfoundland builds up again in October and persists for the rest of the year, and by then the kittiwakes have returned to the southern Scotian Shelf. They reach Georges Bank in December.

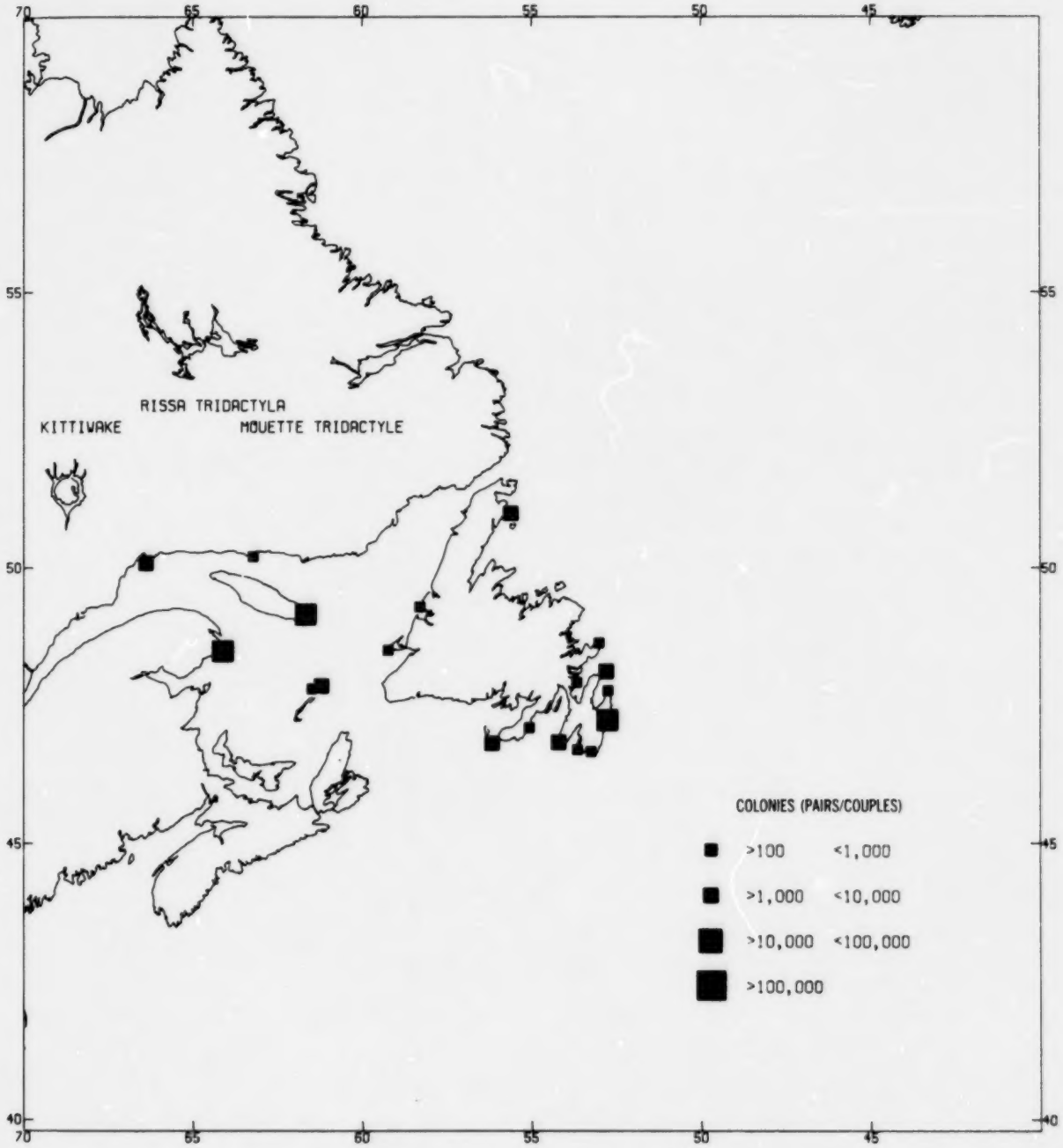
(*c*) *Atlas* maps: Arctic

Aerial surveys show that kittiwakes arrive in northwest Baffin Bay in the middle of May, and numbers peak late in that month (McLaren 1982). At this stage the birds are moving in a broad front offshore, but the ice-edge appears to be an important migration route later in the summer. Numbers build up again in late June, perhaps with the arrival of subadult birds (e.g. Salomonsen 1967). At this season the birds' densities are higher along coasts than at fast-ice edges, and lowest offshore. In all habitats they seem to prefer areas where ice-cover is no greater than 25%. The shipboard surveys show small numbers of kittiwakes present in Lancaster Sound and southern Baffin Bay in July, and larger numbers near the edge of the pack-ice in northeast Baffin Bay; there are none in Hudson Strait. They have become scarcer in the northern part of the Bay in August, and more common from Davis Strait down to Labrador. A few stragglers enter Hudson Strait, but aerial surveys show concentrations inshore, off the northern tip of Labrador, at the eastern entrance (MacLaren 1978, 1979). Aerial surveys show that kittiwakes are common in August–September in the eastern Canadian High Arctic, especially along glaciated stretches of coastline (McLaren and Renaud 1982). The shipboard surveys show that kittiwakes are scarce in northern Baffin Bay in September, and scarcer still in October, and that they have begun to leave Davis Strait by the latter month. The concentrations observed from the air off northern Labrador persist at least until early November, and there is another concentration off Hall Peninsula, southeast Baffin Island, in September–October (MacLaren 1978, 1979).

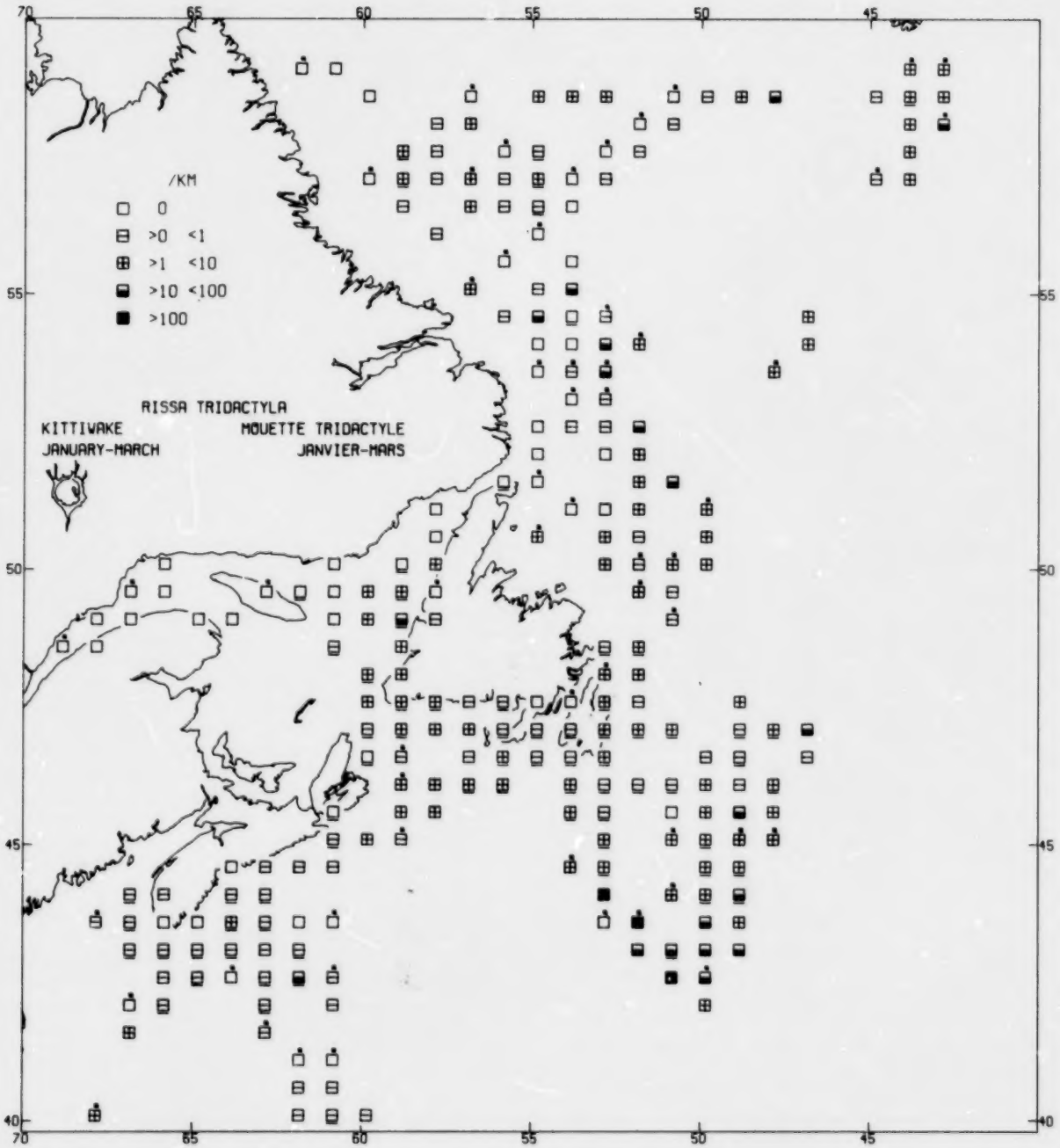
Maps 10a–h

Black-legged Kittiwake distributions

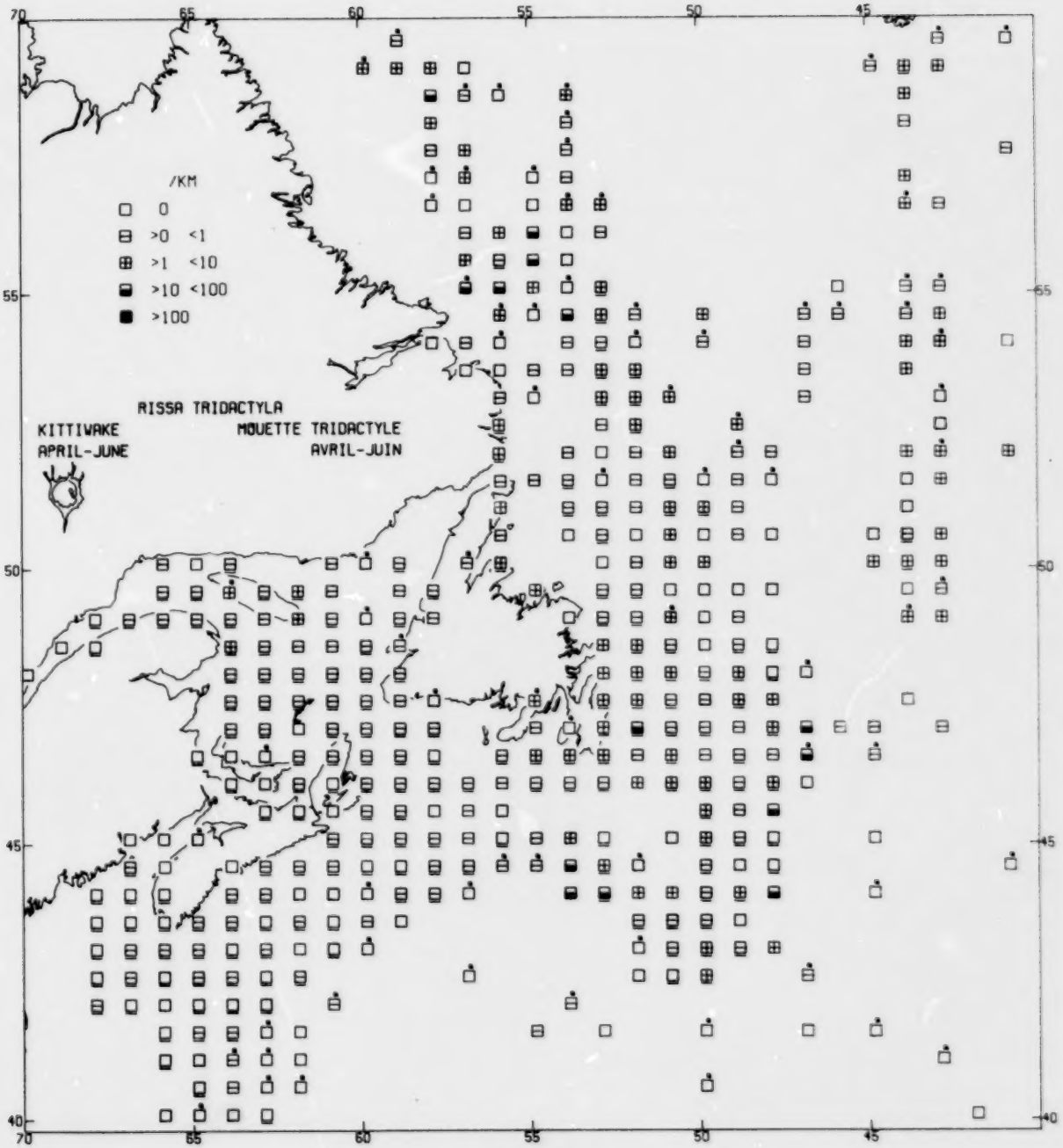
Map 10a
Atlantic colonies



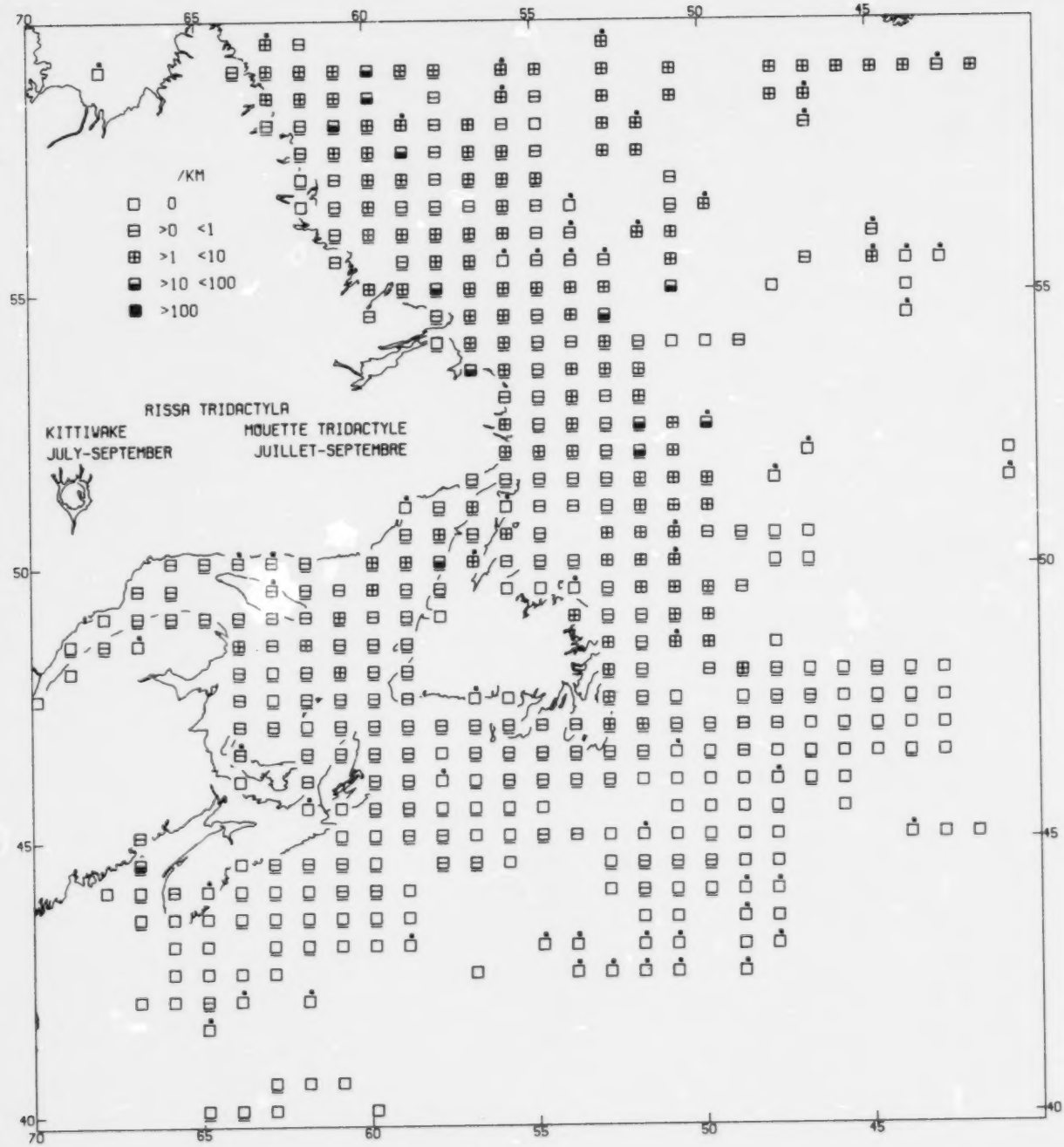
Map 10b
Atlantic, Jaunary–March



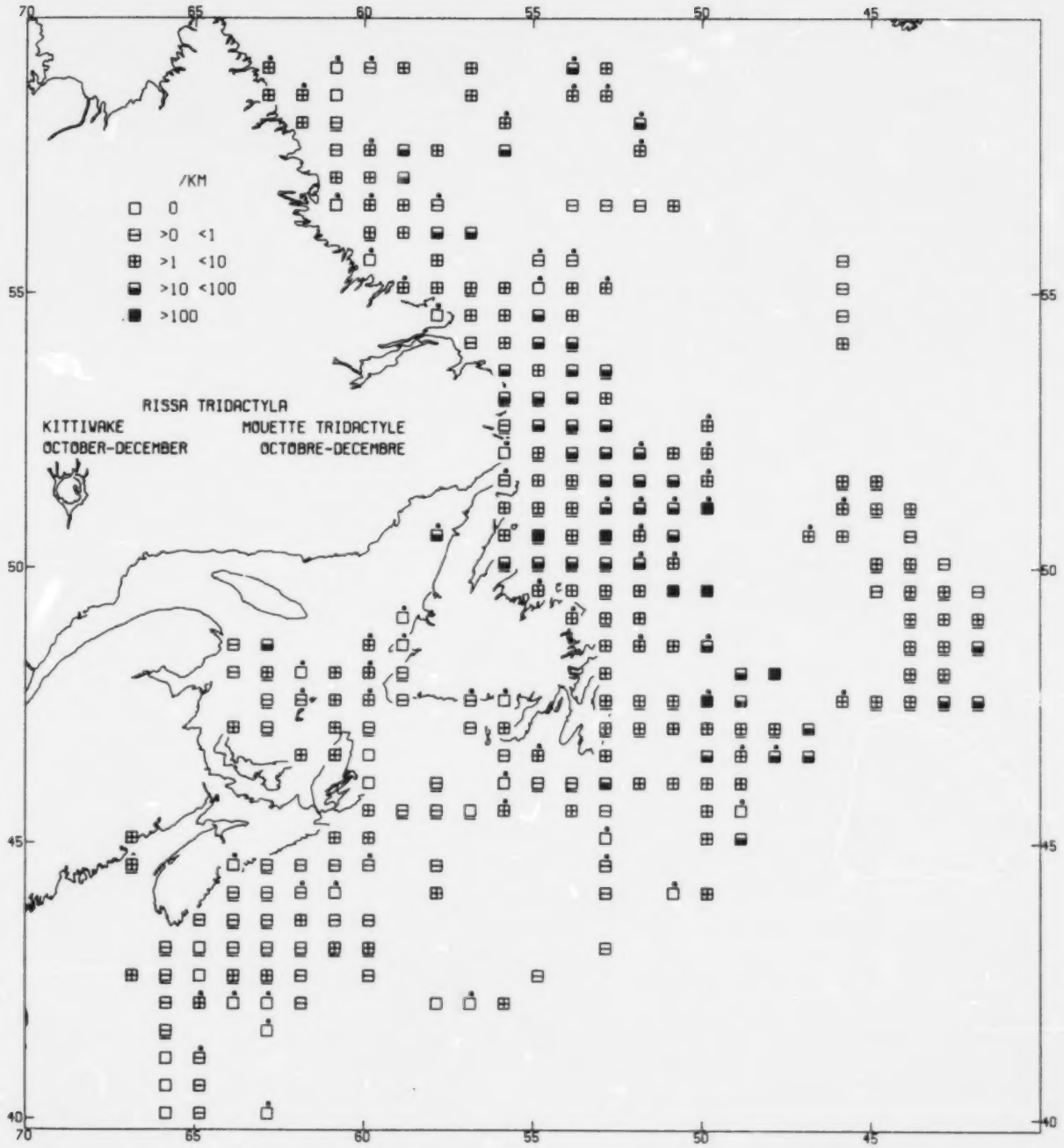
Map 10c
Atlantic, April–June



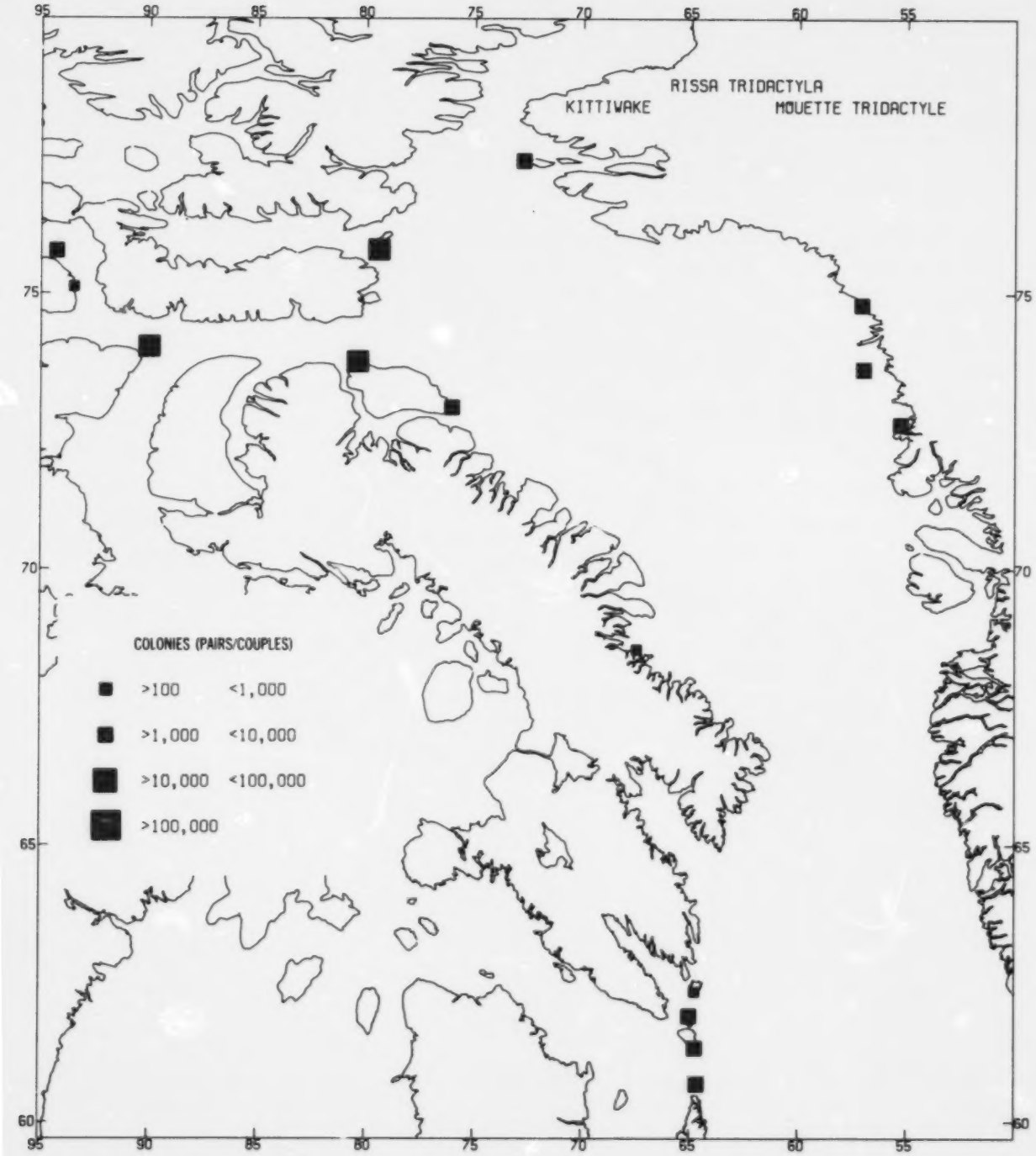
Map 10d
Atlantic, July–September



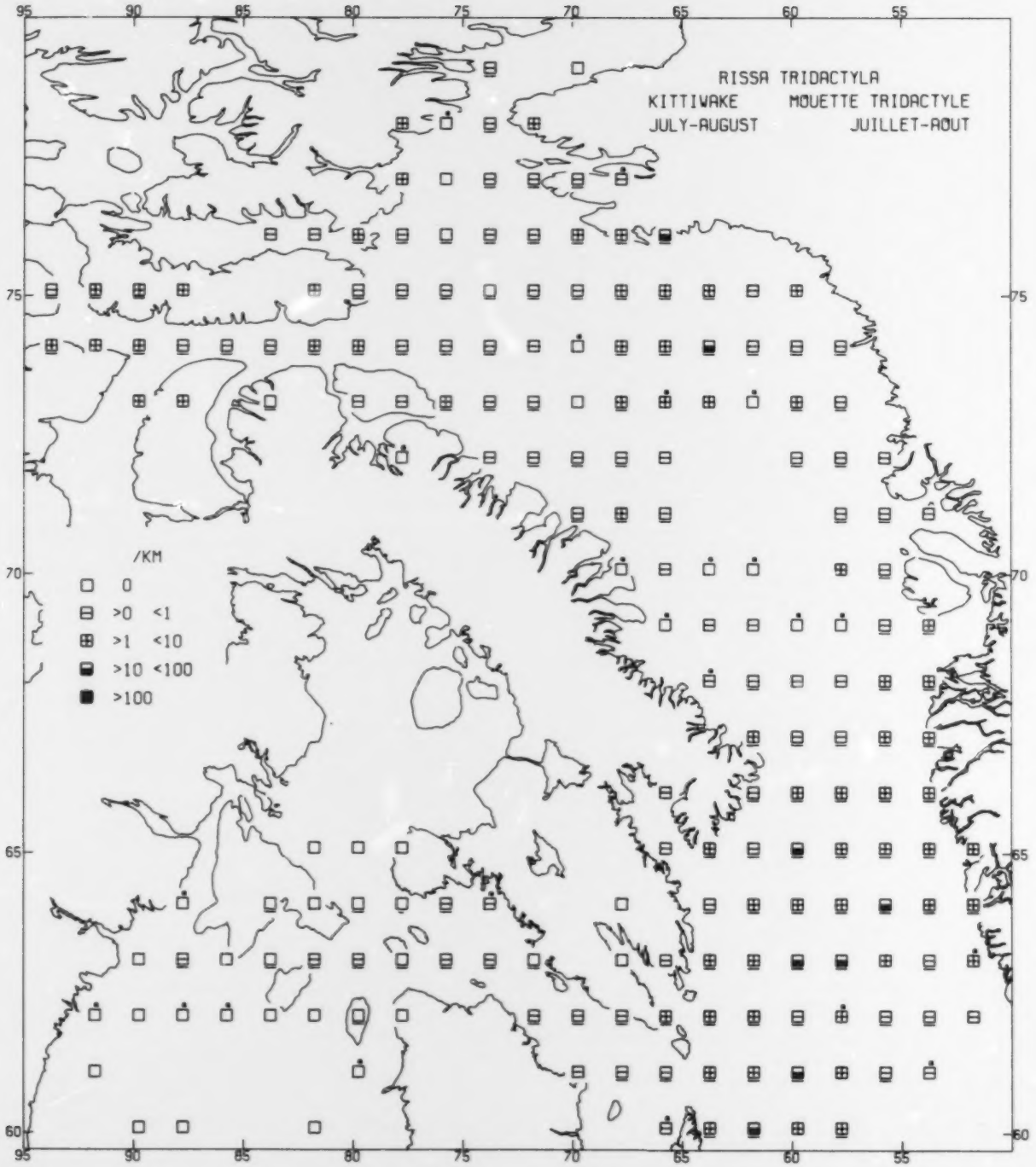
Map 10e
Atlantic, October–December



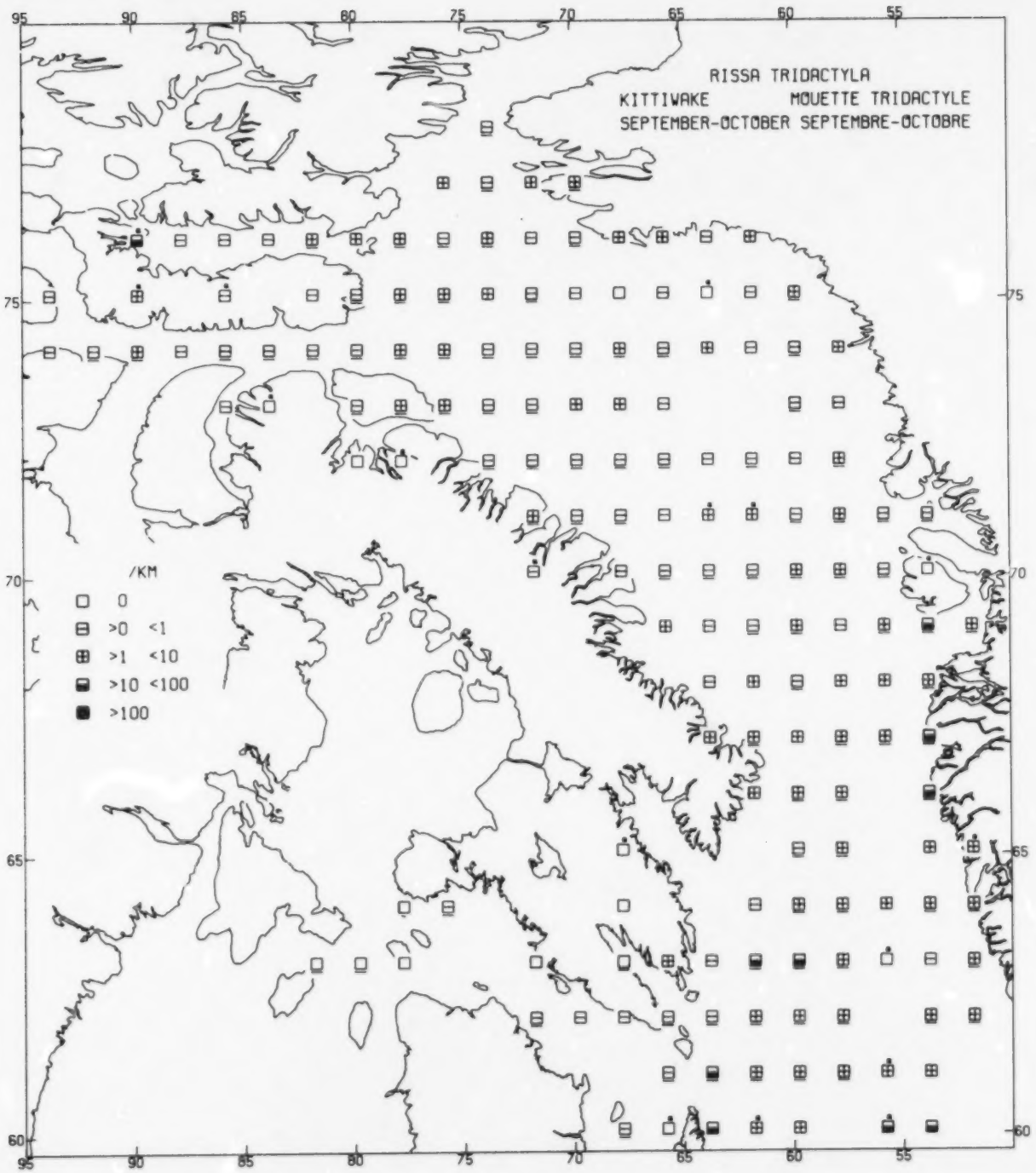
Map 10f
Arctic colonies



Map 10g
Arctic, July–August



Map 10h
Arctic, September–October



5.14. Common Tern (*Sterna hirundo*)
Arctic Tern (*Sterna paradisaea*)
Roseate Tern (*Sterna dougallii*)
Caspian Tern (*Sterna caspia*)

5.14.1. Breeding distribution

Common and Arctic Terns both have circumpolar distributions, the Common Tern in the temperate and subtropical zones and the Arctic Tern in the Low and High Arctic (Salomonsen 1950, 1967; Fisher and Lockley 1954; Godfrey 1966). In eastern North America the Common Tern breeds from the Caribbean and the Gulf of Mexico north to southeast Labrador, with a population in the Great Lakes and farther west. The Arctic Tern breeds in Greenland and the Canadian Arctic south to Hudson Bay, and to New England. In the Atlantic, Roseate Terns breed in the British Isles and on adjacent coasts, the Caribbean, and in eastern North America from Virginia north to New England, with very small populations in Nova Scotia and in the Magdalen Islands, Gulf of St. Lawrence (Fisher and Lockley 1954, Godfrey 1966, Cramp *et al.* 1974, Smith 1979 and pers. commun., Buckley and Buckley 1981). In North America small populations of Caspian Terns breed in southeast Labrador and in Newfoundland; the species also breeds in the Great Lakes and elsewhere in the interior of the continent (Fisher and Lockley 1954, Godfrey 1966, Lock 1983).

Common and Arctic Terns nest in many small colonies and are thus difficult to census; there is no register of occupied sites or overall estimate of the sizes of the populations breeding in the *Atlas* area. There were c. 14 000 pairs of Common Terns and c. 8000 pairs of Arctic Terns in New England around 1970; their numbers initially increased with the cessation of human persecution at the turn of the century, but are declining again due to gull predation (Drury 1973–74). In 1945 Peters and Burleigh (1951) put the populations of Common and Arctic Terns in coastal Newfoundland at 1030 and 2700 pairs respectively. The Roseate Tern population of eastern North America, north of Florida, is only c. 2500 pairs (about 30 of which breed in Nova Scotia)—a drastic decline from c. 8500 in the 1930s, apparently due to excessive hunting on the winter quarters in northeastern South America (Buckley and Buckley 1981).

5.14.2. Pelagic distributions

Both Common and Arctic Terns winter in the Southern Hemisphere, and banding has shown that Arctic Terns undertake some of the longest migrations of any bird (Fisher and Lockley 1954, Salomonsen 1967). Most of the Arctic Terns breeding in the Nearctic apparently move east into the Atlantic at the end of the summer, pass down the west coast of Africa, and winter off South Africa. Some move on to the Atlantic sector of Antarctica, where the species is common at the edge of the pack-ice during the southern summer (e.g. Watson 1975).

These terns are difficult to identify at sea and, because they feed inshore, are seldom seen from ships except while on migration. The birds arrive at their colonies in Atlantic Canada and west Greenland in May and lay in June; the young fledge in July–August (e.g. Peters and Burleigh 1951, Salomonsen 1967, Lock 1973). Terns arrive off New England in April, and reach the Grand Banks, the Scotian Shelf, and the Gulf of Maine in May (Brown *et al.* 1975*a*, Powers 1983). Most June records are close inshore. Terns, presumably Arctics, occur well offshore in July–August on the Labrador Shelf and farther east—presumably early migrants on their way south. They are still common inshore along Atlantic Canadian coasts in August, but almost all the birds have left by late September. A few Arctic Terns remain in September in Baffin Bay, as far north as c. 75°N.

5.15. Dovekie (*Alle alle*)
(Maps 11a–f)

5.15.1. Breeding distribution

The Dovekie is the most abundant seabird in the Arctic. It breeds in large numbers in the Thule District of northwest Greenland (c. 76–78°N), Spitsbergen, Franz Josef Land, Jan Mayen, the Scoresby-Sund region of east Greenland, Novaya Zemlya, and Severnaya Zemlya; there are small populations in west Greenland, Bear Island, northern Iceland, and in the Bering Sea. (Dementeʹev and Gladkov 1951, Freuchen and Salomonsen 1958, Breckenridge 1966, Brown *et al.* 1975*a*, Meltofte 1976, Norderhaug *et al.* 1977, Roby *et al.* 1981, Petersen 1982). Small numbers also breed in Home Bay, eastern Baffin Island (69°02′N, 67°23′W)—the only known colony in Canada (Finley and Evans 1984). The majority of the world population breeds in Thule District, where Freuchen and Salomonsen (1958: 196) suggest there may be 30 million birds; aerial surveys have shown that there are at least 14 million in the waters off Thule in May (Renaud *et al.* 1982). Freuchen and Salomonsen suggest populations of c. 10 million birds in both Scoresby-Sund and Spitsbergen, and "probably not much less" in Novaya Zemlya, Jan Mayen, and Franz Josef Land. This, however, certainly exaggerates numbers in the first three areas named (Meltofte 1976, Norderhaug *et al.* 1977). The breeding distribution in west Greenland is shown in Map 11a.

Dovekies arrive in Thule District during the first half of May, and lay their single eggs in the middle of June; the young birds hatch towards the end of July and fledge in mid-August. The colonies are abandoned during the last week in August (Salomonsen 1950, 1967; Freuchen and Salomonsen 1958).

5.15.2. Pelagic distribution

(*a*) General

Although large numbers of Dovekies have been banded in Thule District, there have been only three recoveries away from the colonies—all from eastern Newfoundland in November–January (Salomonsen 1971*a*, 1979*c*). Dovekies are hunted intensively in southwest Greenland in winter, but the 14 banded birds recovered there, almost all in November–January, had all come from Spitsbergen (Norderhaug 1967; Salomonsen 1967, 1971*b*; Holgersen 1980). Salomonsen (1967) concluded from this that the whole of the Thule

population winters in the western Atlantic, mainly off Newfoundland. He suggested that birds from the European High Arctic move southwest at the end of the breeding season and winter in the northeast Atlantic, with the vanguard reaching southwest Greenland. It is not known whether any also reach Newfoundland waters.

Dovekies are notorious for being carried far out of their normal range by winter storms (Fisher and Lockley 1954). Flocks of birds are regularly "wrecked" on the eastern seaboard of North America, and on the coasts of southwest Europe, and stray birds have even reached Cuba, the Canaries, and the western Mediterranean.

(*b*) *Atlas* maps: Atlantic

In January–March Dovekies are fairly common on the Scotian Shelf, the Grand Banks, and the Labrador Shelf, though their access to Labrador waters is limited by the extent of pack-ice there in late winter and spring (e.g. Anon. 1968). There are large local concentrations of birds at the shelf-breaks in all three areas. Small numbers occur as far south as Georges Bank at this time of year, especially at the northeastern corner (Powers 1983). The birds leave Georges Bank and the Scotian Shelf in April and May, but are still common on the Grand Bank; as the breeding birds have returned to Thule District by then, those still in the south are probably subadults (Freuchen and Salomonsen 1958, Renaud *et al.* 1982). Birds in the deep water east of the Labrador Shelf in May are migrants on their way north (Brown 1968: Fig. 1). Dovekies leave the Grand Banks in June and, apart from a few stragglers (Brown *et al.* 1975*a*), are absent from Canadian Atlantic waters until October, when the vanguard of the fall migration arrives off eastern Newfoundland. The birds reach the Scotian Shelf and Georges Bank in November–December.

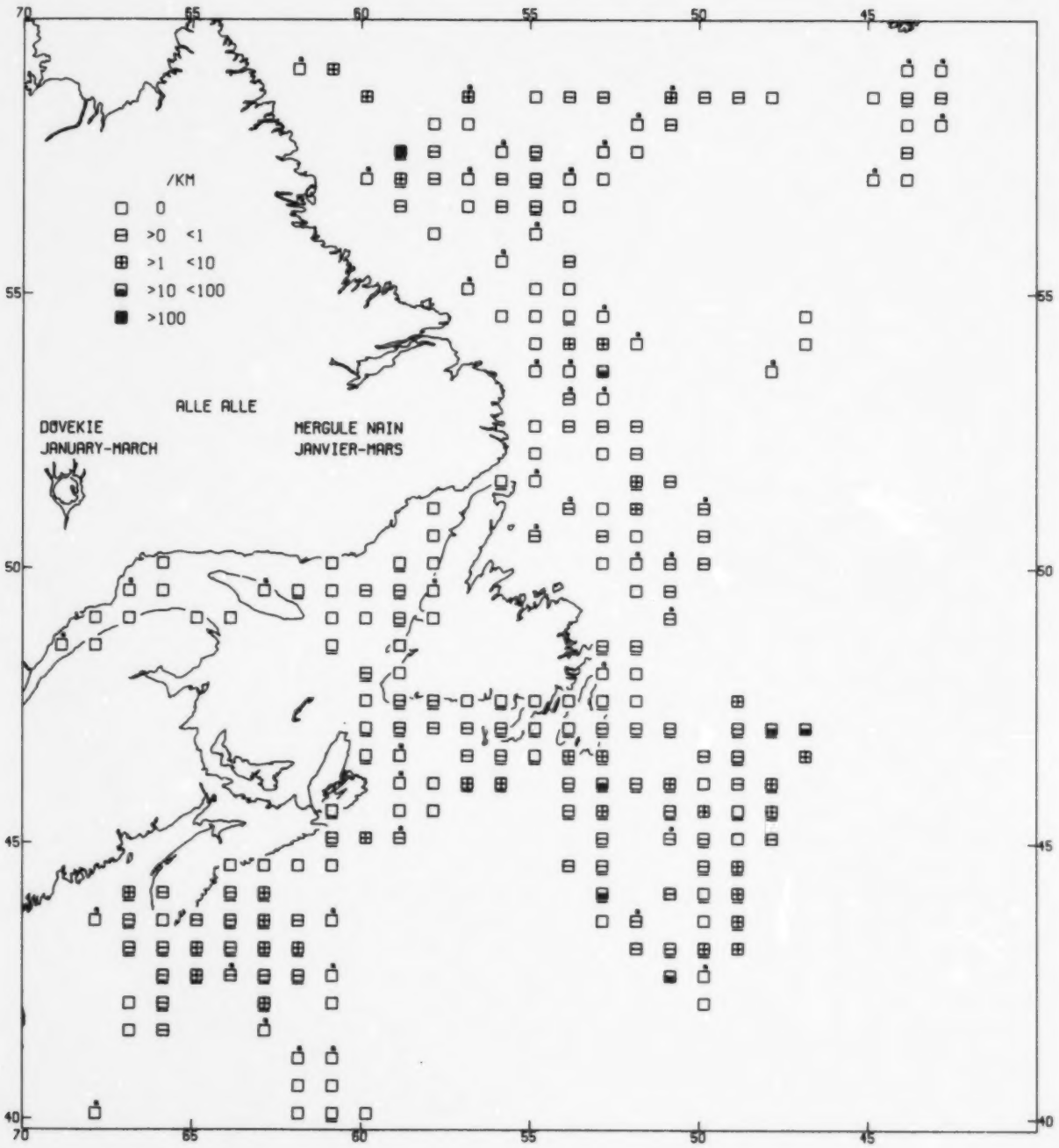
(*c*) *Atlas* maps: Arctic

The Dovekies that winter off southwest Greenland leave there in April (Salomonsen 1967). Aerial surveys show that the timing of the arrival of the Thule District population in northwest Baffin Bay varies a little from year to year, but the birds get there in the middle of May, and most of the passage is over by the end of that month (Renaud *et al.* 1982). Dovekies are more common offshore than at the nearshore ice-edge and, when in ice, apparently prefer areas where c. 51–75% of the surface of the water is covered. The shipboard maps presented here show that Dovekies are abundant close to their Thule colonies in July, with scattered birds farther south—though there is not much information for western Baffin Bay at this time of year. The birds are still abundant off Thule in August; they are also common at the ice-edge off the west coast of Baffin Island, all the way south to Davis Strait (see also Brown 1980*a*: Fig. 3). As the population of Dovekies breeding in Greenland south of Thule is very small (Brown *et al.* 1975*a*), the latter birds are presumably non-breeders. The birds abandon Thule and northeast Baffin Bay in September but remain at the ice-edge in Baffin Bay; their southern limit is now c. 62°N, off the eastern entrance to Hudson Strait. Dovekies are scarce in northern Baffin Bay in October, though the birds are still quite common in Davis Strait, and they have spread south to Labrador and Newfoundland (see above). Birds from the European Arctic begin to arrive off southwest Greenland in October–November (Salomonsen 1967, 1971*b*).

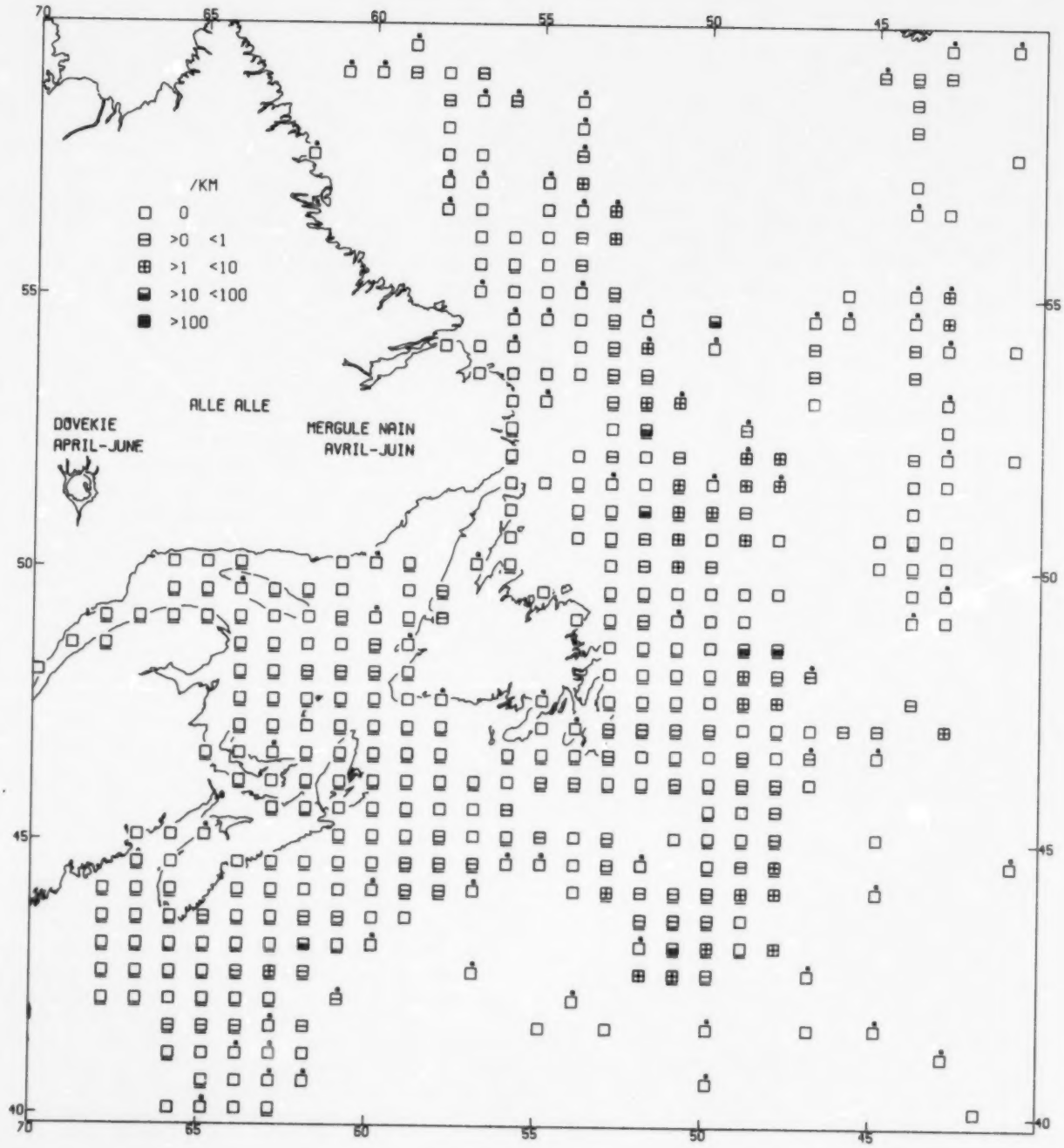
Maps 11a–f

Dovekie distributions

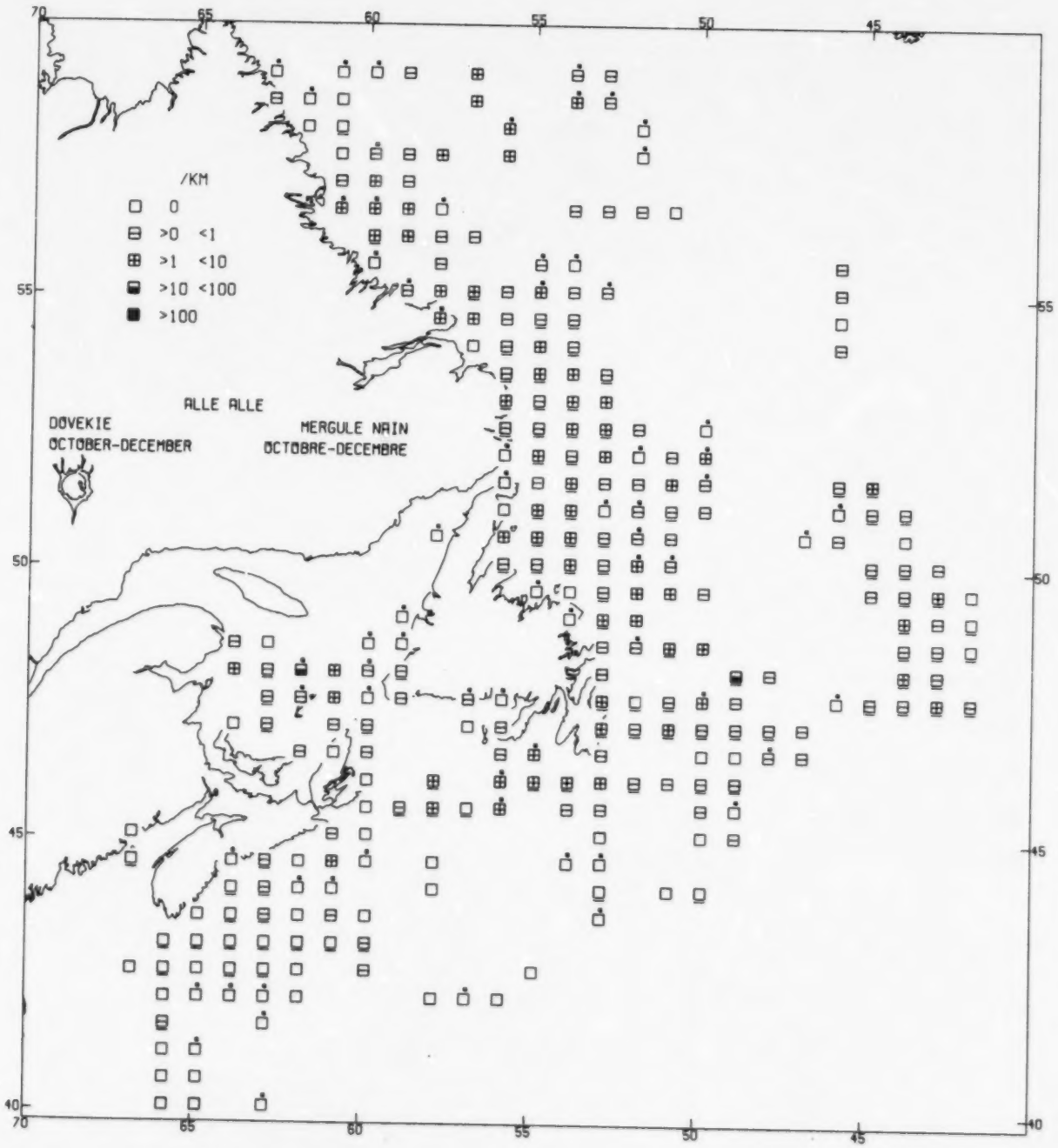
Map 11a
Atlantic, January–March



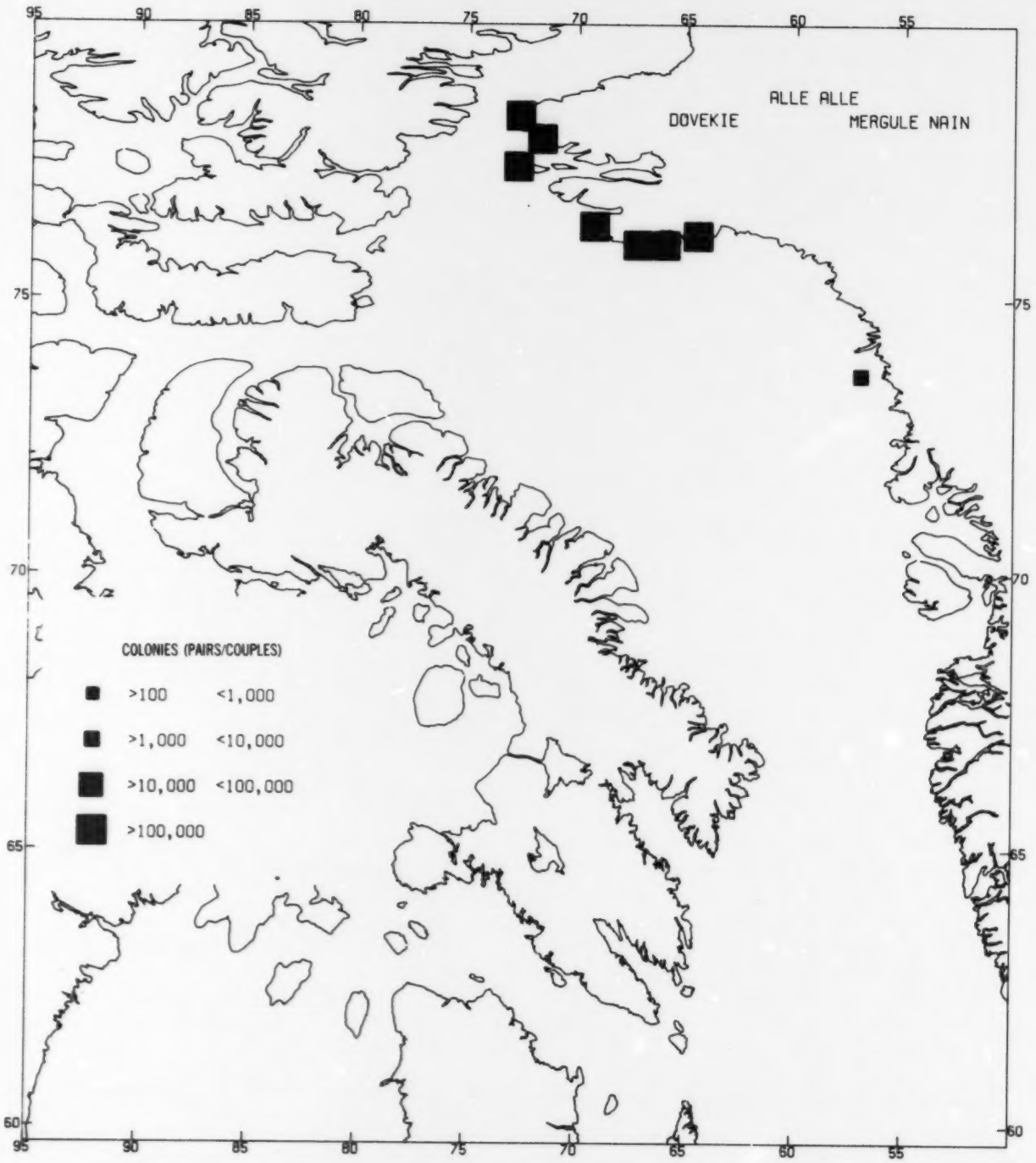
Map 11b
Atlantic, April–June



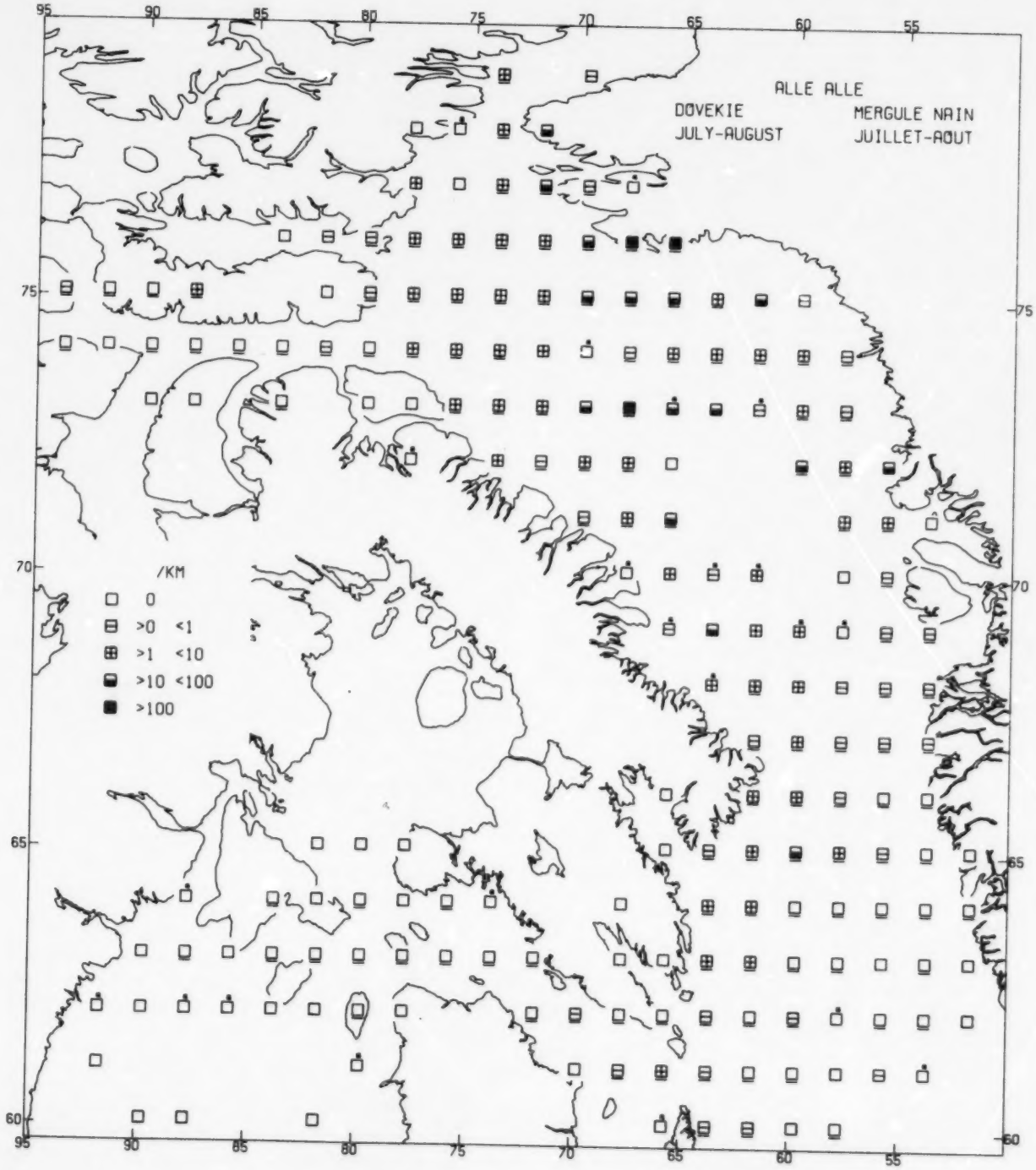
Map 11c
Atlantic, October–December



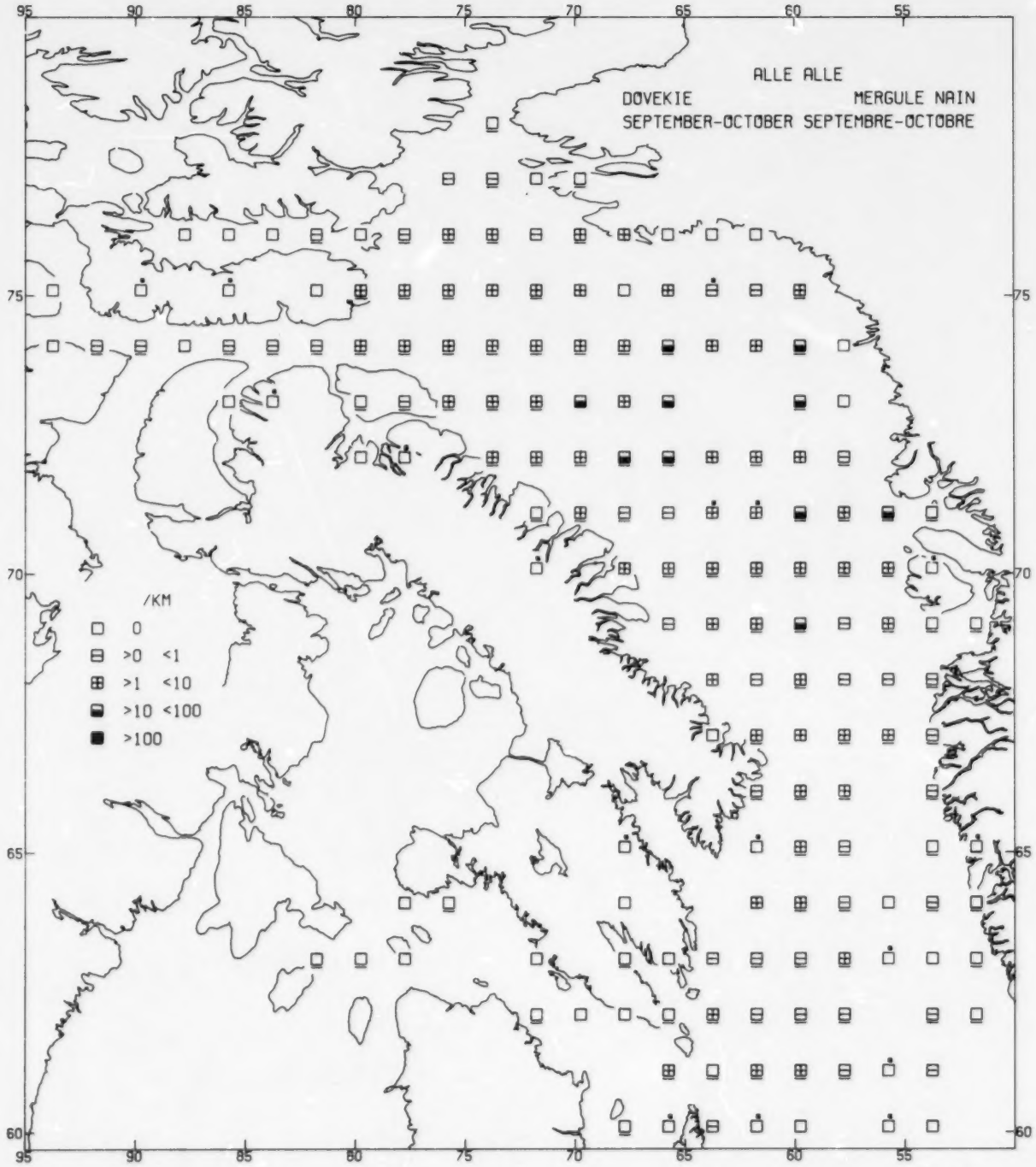
Map 11d
Arctic colonies



Map 11e
Arctic, July–August



Map 11f
Arctic, September–October



5.16. Common Murre (*Uria aalge*) (Maps 12a–e, 14a–f) Thick-billed Murre (*Uria lomvia*) (Maps 13a–f, 14 a–f)

5.16.1. Breeding distributions

The Common and Thick-billed Murres are the largest extant alcids. They are, respectively, Boreal and Arctic species in both the North Atlantic and North Pacific, though their distributions overlap to a certain extent.

The Common Murre population in the North Atlantic is of the order of 3 million pairs. The species breeds in Atlantic Canada (c. 630 000 pairs), Iceland (c. 1.6 million), Faeroe (c. 393 000), Britain and Ireland (c. 577 000), Norway (c. 100 000), the Murmansk Coast (c. 15 000), and Novaya Zemlya (c. 10 000), and there are also small populations in southwest Greenland, northwest Spain, Portugal, Heligoland, and the western Baltic (Fisher and Lockley 1954, Tuck 1961, Cramp *et al.* 1974, Brown *et al.* 1975*a*, Dyck and Meltofte 1975, Norderhaug *et al.* 1977, Brun 1979, Einarsson 1979, Salomonsen 1981, Petersen 1982). Most of the birds in Atlantic Canada breed in eastern Newfoundland, especially on Funk Island (49°45′N, 53°51′W: c. 500 000 pairs), but also in the northern Gulf of St. Lawrence and in southeast Labrador (Brown *et al.* 1975*a*; see also Map 12a). The Greenland population consists of an unknown number of Common Murres among the large Thick-billed Murre colony in Sermilinguaq Fjord, southwest Greenland (Salomonsen 1981; the site is indicated by an asterisk in Fig. 13a).

The Thick-billed Murre population in the North Atlantic is of the order of 10 million pairs. The subspecies *U.l.lomvia* breeds in Atlantic Canada (>2000 pairs), the eastern Canadian Arctic (c. 1.22 million), west Greenland (c. 1.12 million), Iceland (c. 2 million), Svalbard (order 2 million), Novaya Zemlya (c. 1.88 million), the Murmansk coast (c. 5000), and Norway (c. 1000), and there are also fairly large populations, of unknown size, on Jan Mayen, Franz Josef Land, Severnaya Zemlya, and the Scoresby-Sund region of east Greenland (Salomonsen 1950, 1967, 1981; Fisher and Lockley 1954; Tuck 1961; Joensen and Preuss 1972; Brown *et al.* 1975*a*; Norderhaug *et al.* 1977; Einarsson 1979; Gaston 1982; Petersen 1982.) The eastern Canadian population breeds in western Baffin Bay, in Lancaster Sound and Hudson Strait and, in small numbers, in Labrador, Newfoundland, and the Gulf of St. Lawrence (Brown *et al.* 1975*a*; see also Map 13a).

There is an isolated colony of c. 100 pairs of Thick-billed Murres in the western Canadian Arctic at Cape Parry (70°12′N, 124°32′W: Nettleship and Smith 1975). This is almost halfway between the colonies in the eastern Arctic, with the nearest ones in the Chukchi Sea to the west. It is not known whether these birds belong to the Atlantic or the Pacific subspecies, or where they spend the winter.

In Atlantic Canada, Common Murres return to their colonies during the last half of March, and lay their single eggs towards the end of May (Tuck 1961). The chicks hatch at the beginning of July. Young Common Murres, like young Thick-billed Murres and Razorbills (q.v.), leave their colonies before they can fly and swim off accompanied by a parent. This takes place in mid-July in Newfoundland colonies, but not until early August in southeast Labrador.

Thick-billed Murres reach the Low Arctic parts of west Greenland during the last half of April, and the High Arctic in mid-May (Salomonsen 1950, 1967). The first eggs in Greenland and Newfoundland colonies are laid during the first week of June, but not until mid or late June in Hudson Strait and Lancaster Sound (Salomonsen 1950, 1967; Tuck 1961; Gaston and Nettleship 1981). West Greenland chicks first go to sea at the end of July, but birds from Canadian colonies usually do not leave until the last third of August.

5.16.2. Pelagic distributions

(*a*) General

The banding data suggest that the Atlantic Canadian population of Common Murres is a self-contained unit, not augmented by immigration from other areas in winter, except perhaps from west Greenland (Tuck 1961, 1971). Tuck believed that Newfoundland birds dispersed northwards after they left the colonies. It is more likely that dispersal is random, and that the apparent northward movement is a consequence of the greater length of coastline in that direction, and hence the better chances of band recoveries (A.J. Gaston, CWS, pers. commun.). It is probable that Common Murres move southwards later in the year. This was the dominant species of murre killed in the *Argo Merchant* oil spill off Massachusetts between December 1976 and January 1977 (Powers and Rumage 1978). By contrast, Thick-billed and not Common Murres have been dominant in oil-spill kills off Nova Scotia and southern Newfoundland in winter and early spring (Tuck 1961, Brown *et al.* 1973, Brown and Johnson 1980). Common Murres also make up only a small proportion of the murres in the winter hunting harvest in eastern Newfoundland (Gaston *et al.* 1983).

The movements of Thick-billed Murres in the western Atlantic are complex. Analysis of banding returns suggests that all the birds from the colonies in Hudson Strait, all the young and many of the adults from west Greenland, and many of the birds from Lancaster Sound winter off Newfoundland (Tuck 1961, 1971; Salomonsen 1967, 1971*b*; Gaston 1980; Kampp 1982). Young birds from Greenland and the Canadian Arctic begin to arrive in September–October, but older birds not until November. Gaston estimated that something of the order of 4 million Thick-billed Murres reach our waters from the Arctic in November–January: roughly 53% of these are from Hudson Strait and southeast Baffin Island, 27% from west Greenland, and 19% from Lancaster Sound. Some also come from east Greenland; only a few birds have been banded there, but one of the three recoveries was in Newfoundland (Salomonsen 1979*c*, Kampp 1982). Salomonsen suggested that east Greenland murres winter in the deep waters south of Greenland, but the *Atlas* maps do not support this. It is more likely that these murres (and perhaps birds from other colonies in the eastern Atlantic) winter on the eastern Grand Bank, but so far offshore that the chance of any banding recoveries is negligible.

The remaining Thick-billed Murres from the Lancaster Sound and west Greenland colonies probably winter off west Greenland (Tuck 1961, Salomonsen 1967, Gaston 1980, Kampp 1982). They are joined by birds from colonies in Svalbard and, to a lesser extent, from the Murmansk coast and Novaya Zemlya, and remain off southwest Greenland from November to February (Salomonsen 1967, 1971*b*; Kampp 1982). The proportion of European Arctic birds in the population of murres wintering off Greenland is unknown, but Salomonsen (1967) suggests that most European birds winter in the eastern Atlantic, and that relatively few disperse as far west as Greenland.

Banding shows that Greenland Thick-billed Murres do not begin to breed until they are 5 years old (Salomonsen 1967, Kampp 1982). Very few 1st-year and 2nd-year birds are recovered near their natal colonies in summer. Older subadults do come back, but they tend to be recovered farther away from the colonies than are the adults.

(*b*) *Atlas* maps: Atlantic

It is difficult to separate Common and Thick-billed Murres at sea, and both may be confused with the Razorbill (q.v.). The usual quantified maps of the two species' distributions in the western Atlantic are therefore not shown. Instead, the *Atlas* shows quantified maps of murres only, combining the two species (Maps 14 a–f). A separate set of maps uses "+" to indicate a 30′N × 1°W block in which at least one Thick-billed Murre, for example, was positively identified during the month in question; "−" shows where murres and/or Razorbills were present, but where Thick-billed Murres were not positively identified; "o" shows where no murres or Razorbills were seen at all. Blank areas, as usual, show where no observations were made. All watch-reliabilities and ships' speeds have been used in compiling these "+/−/o" species maps.

Murres are present on the Labrador Shelf, the Grand Banks, the Scotian Shelf, Georges Bank, and the eastern Gulf of St. Lawrence from January to May, and towards the end of that period they appear in the deeper waters south of Greenland—presumably Thick-billed Murres either returning from Greenland to the European Arctic (see above), or from Newfoundland to Greenland (Brown 1968). Thick-billed Murres are positively identified over most of this range, but Common Murres are largely confined to the southern part of it. Inshore concentrations of birds off southeast Newfoundland in March and April are almost certainly Common Murres returning to the large colonies on that coast (Brown *et al.* 1975*a*). From May to July murres—mainly Common Murres—are most abundant close to the colonies in eastern Newfoundland, the western Gulf of St. Lawrence, and southeast Labrador. The maps suggest that the eastern Newfoundland birds may be foraging as far offshore as the northern Grand Bank. The increase in Common Murre identifications well offshore of eastern Newfoundland and southeast Labrador in July and August probably reflects the dispersal of adults and chicks from the colonies at this time. The northward migration of Thick-billed Murres passes across the Labrador Shelf and Sea in May, but a few birds remain on the Shelf all summer, presumably non-breeding subadults. However, the apparent increase of Thick-billed Murres on the Labrador Shelf in August also reflects the dispersal of adults and chicks from the colonies in Labrador, and perhaps also from Hudson Strait. The Common Murres in the Bay of Fundy in July–September probably came from a small colony of less than 100 pairs on Yellow Murr Ledge (44°31′N, 66°52′W), southwestern New Brunswick (Vickery 1982); however, the Thick-billed Murres were either very early migrants from farther north, or were misidentified. The southward migration of Thick-billed Murres down the Labrador Shelf in October is very clear; the birds seem to abandon the northern part of the Shelf in November–December and to come as far south as the waters east of Cape Breton.

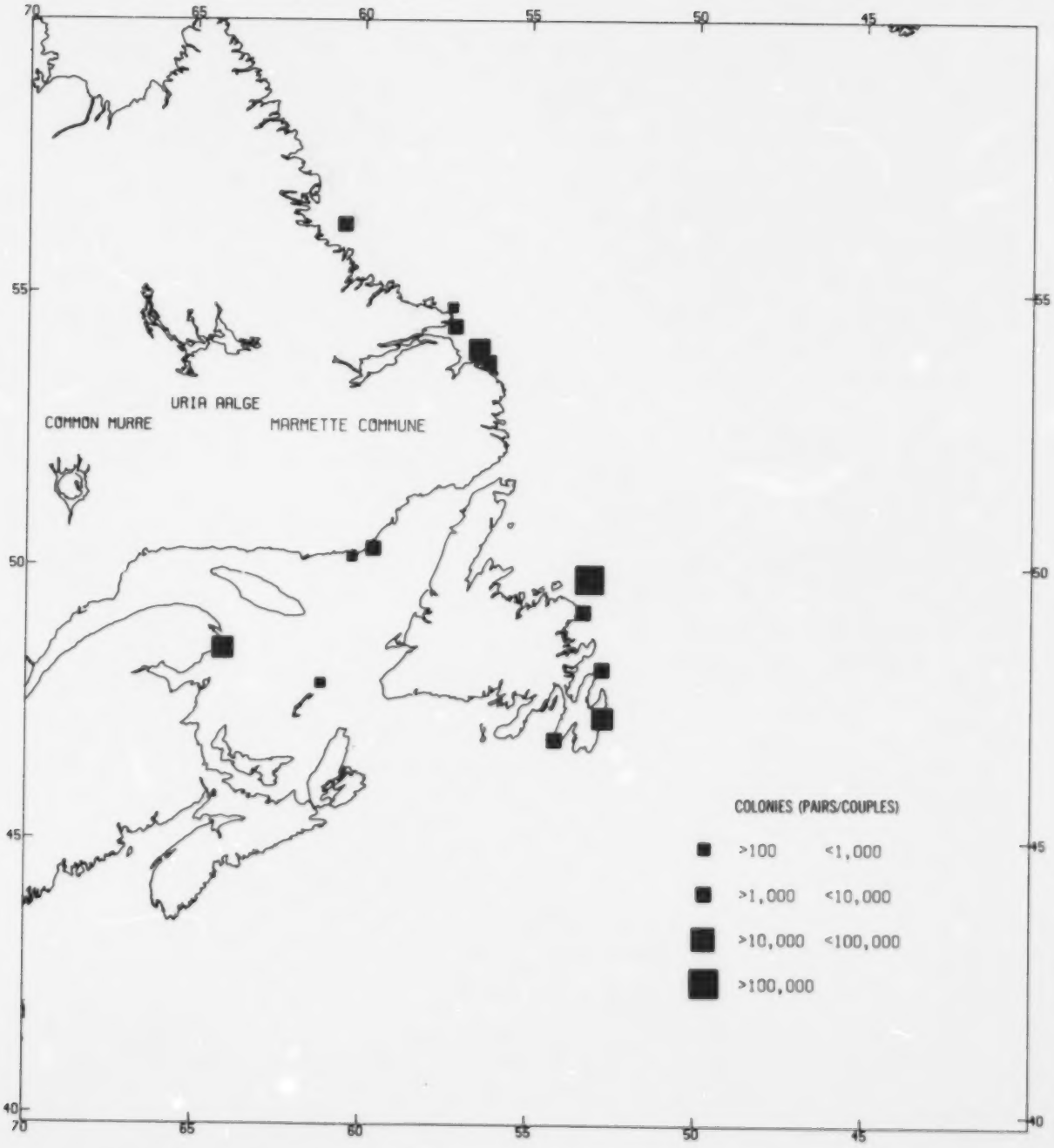
(*c*) *Atlas* maps: Arctic

It may be assumed from the composition of the colonies north of 60°N (see above) that virtually all the large auks seen in the Arctic are Thick-billed Murres. Aerial surveys in northwest Baffin Bay (McLaren 1982) show that large numbers passed through the area in mid-May, presumably en route to the colonies in Lancaster Sound and northwest Greenland. There was a second peak in June in some years, perhaps reflecting the arrival of the older subadult birds (see above). Densities are higher along the edges of the fast-ice than along ice-free coasts; the birds seem to prefer water with ice-cover of <25%. Other aerial surveys (MacLaren 1978, 1979) show some evidence of a passage off northeast Labrador in mid-May. The shipboard surveys show that Thick-billed Murres are scarce in offshore waters in Baffin Bay in July–August, but locally abundant close to the large colonies in Hudson Strait, Lancaster and Jones Sounds, eastern Baffin Island, and west and northwest Greenland. Most birds leave northern Baffin Bay and the adjacent Sounds in September, but they are still fairly common from southern Baffin Bay to Hudson Strait, and remain so in October. Aerial surveys show that swimming murre chicks and their parents remain in eastern Hudson Strait until the last week in September (Orr and Ward 1982). All murres seem to have left the Strait and northern Labrador by November.

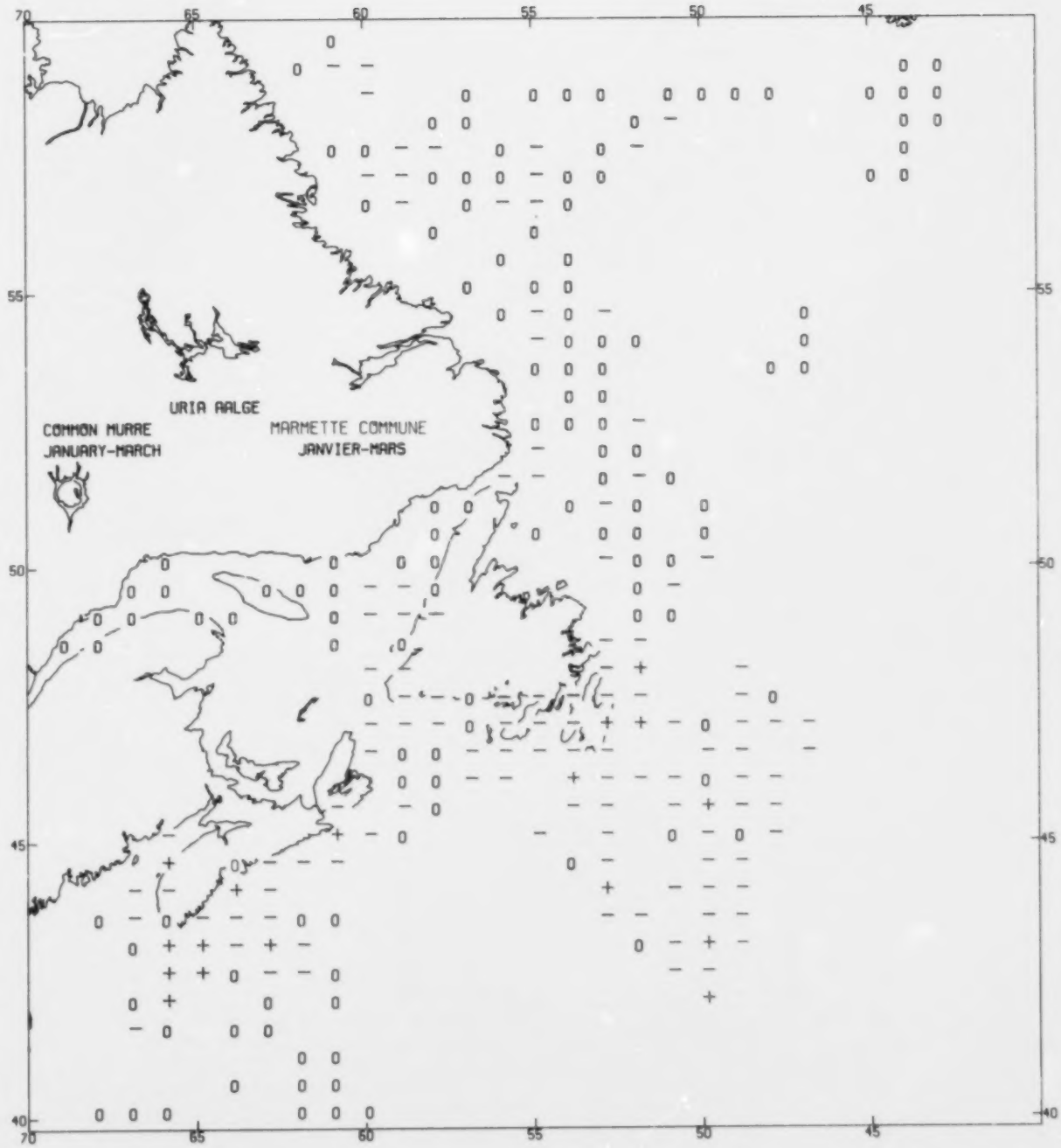
Maps 12a–e

Common Murre distributions

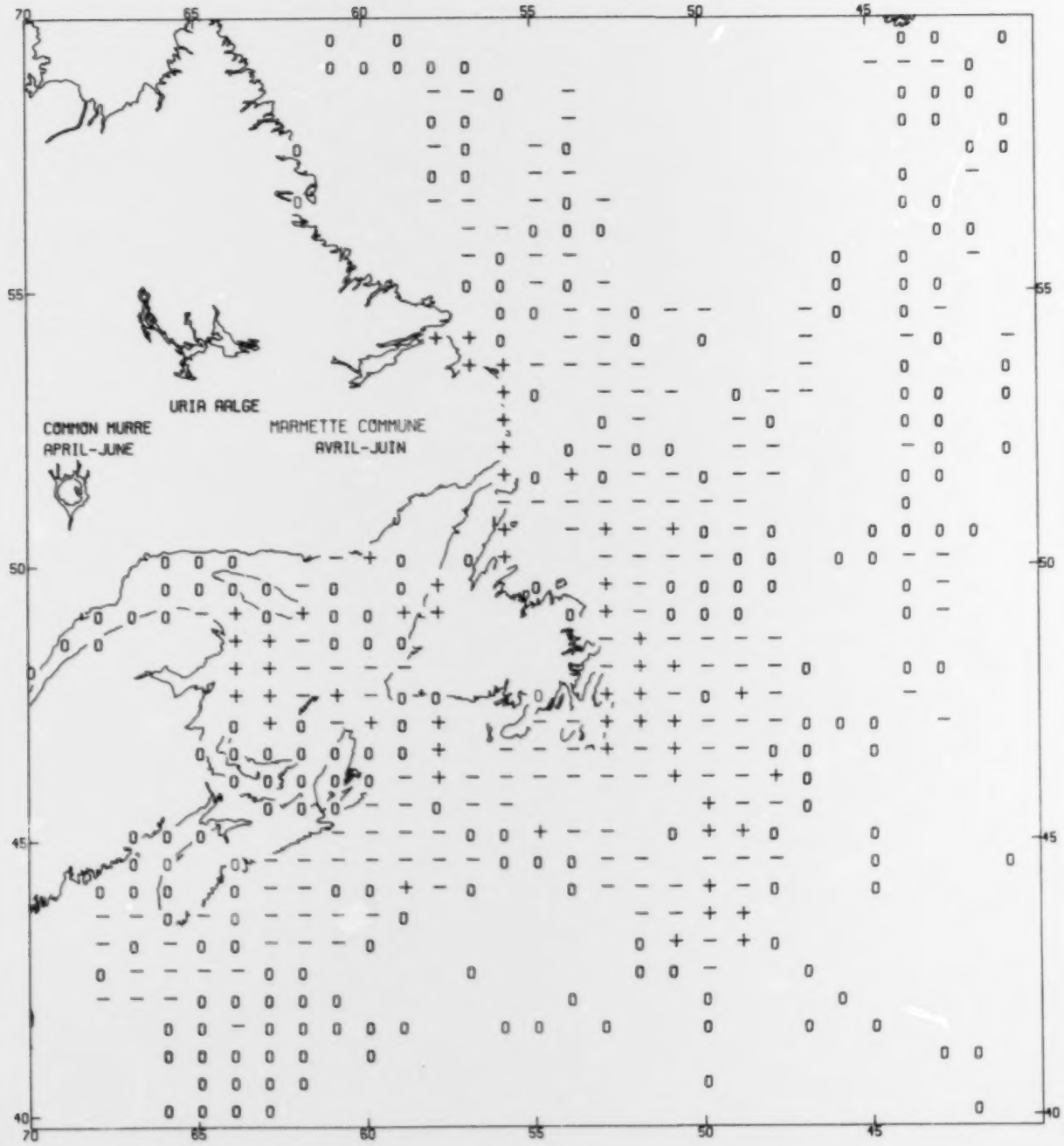
Map 12a
Atlantic colonies



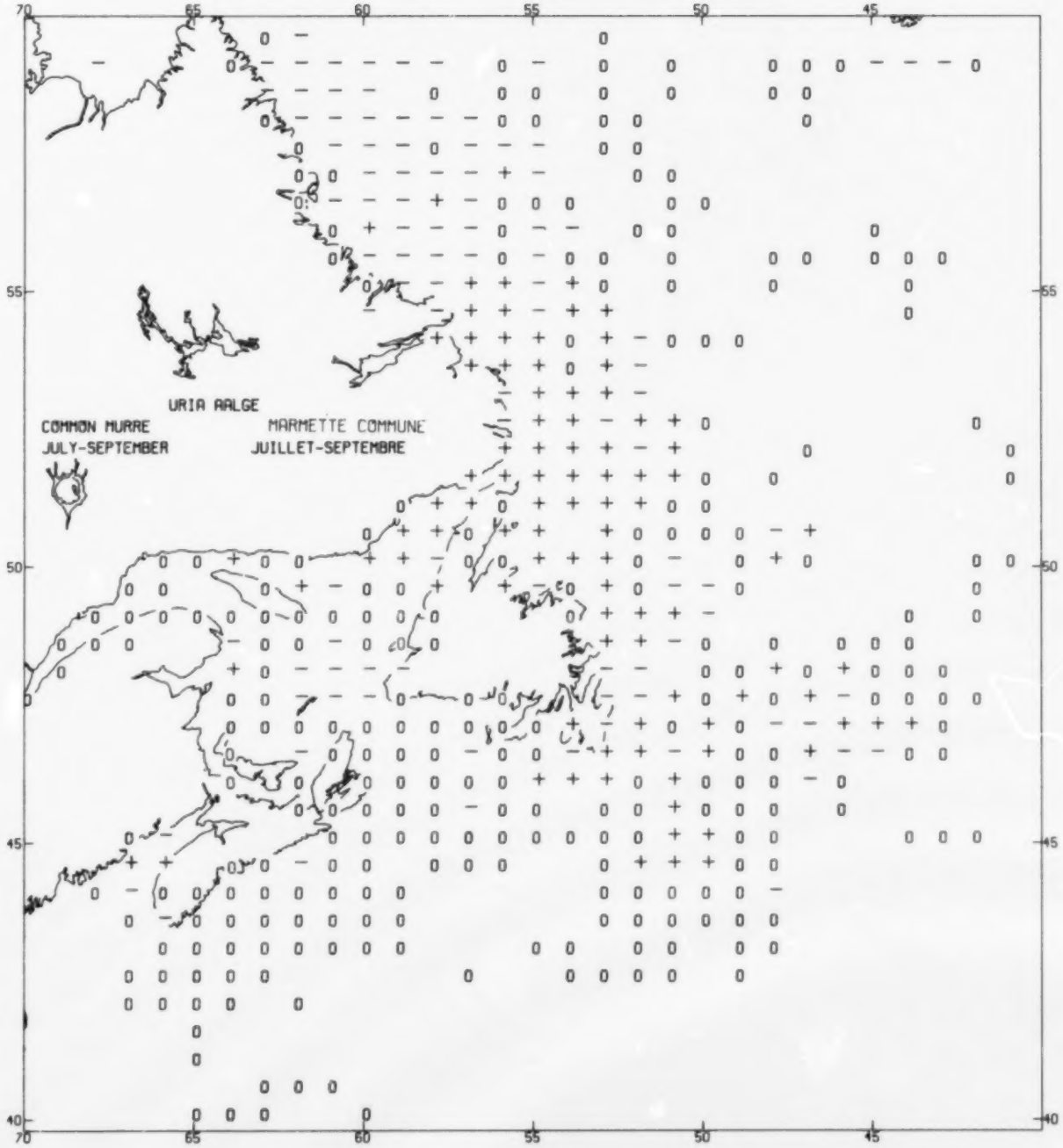
Map 12b
Atlantic, January–March



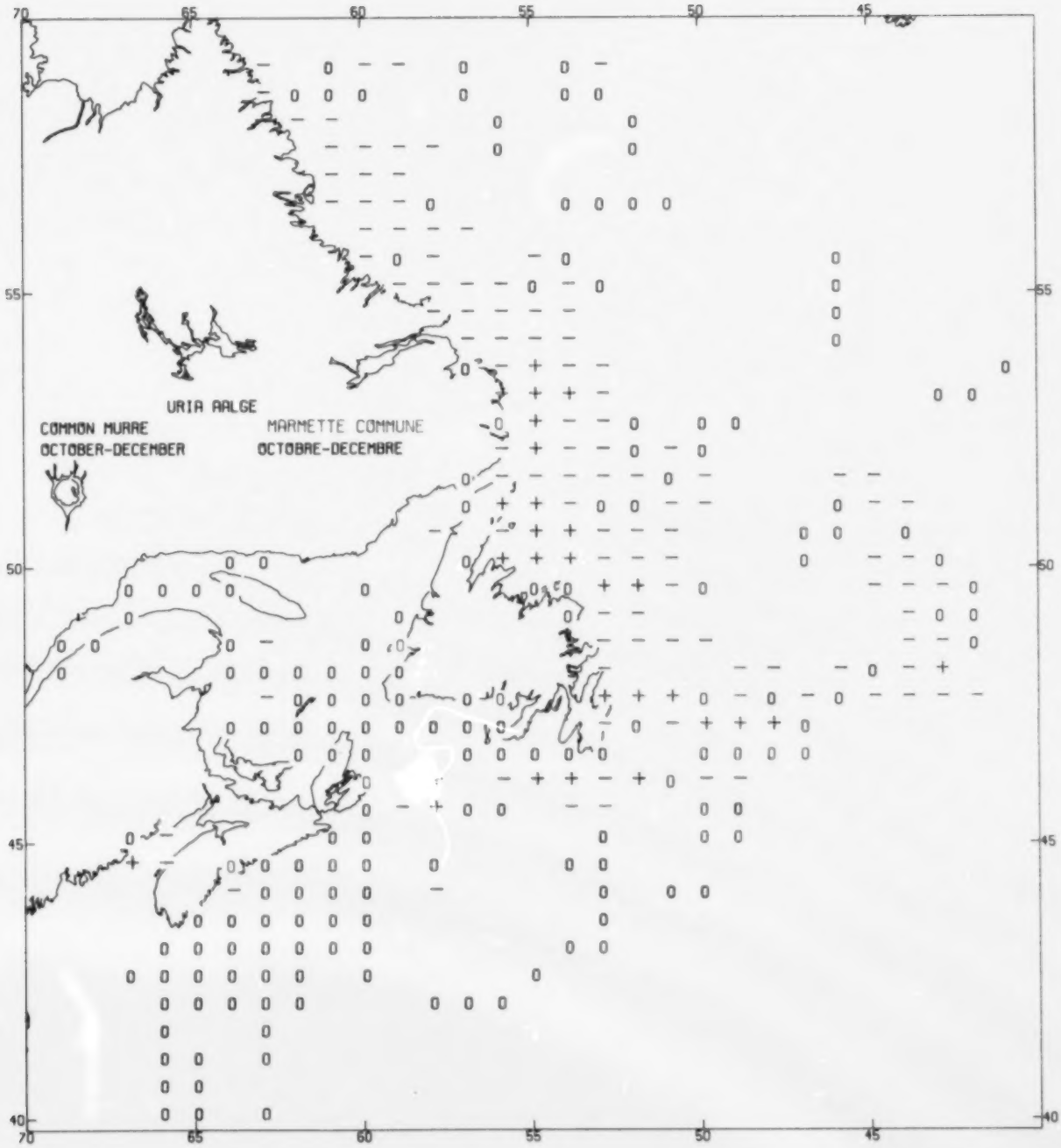
Map 12c
Atlantic, April–June



Map 12d
Atlantic, July–September



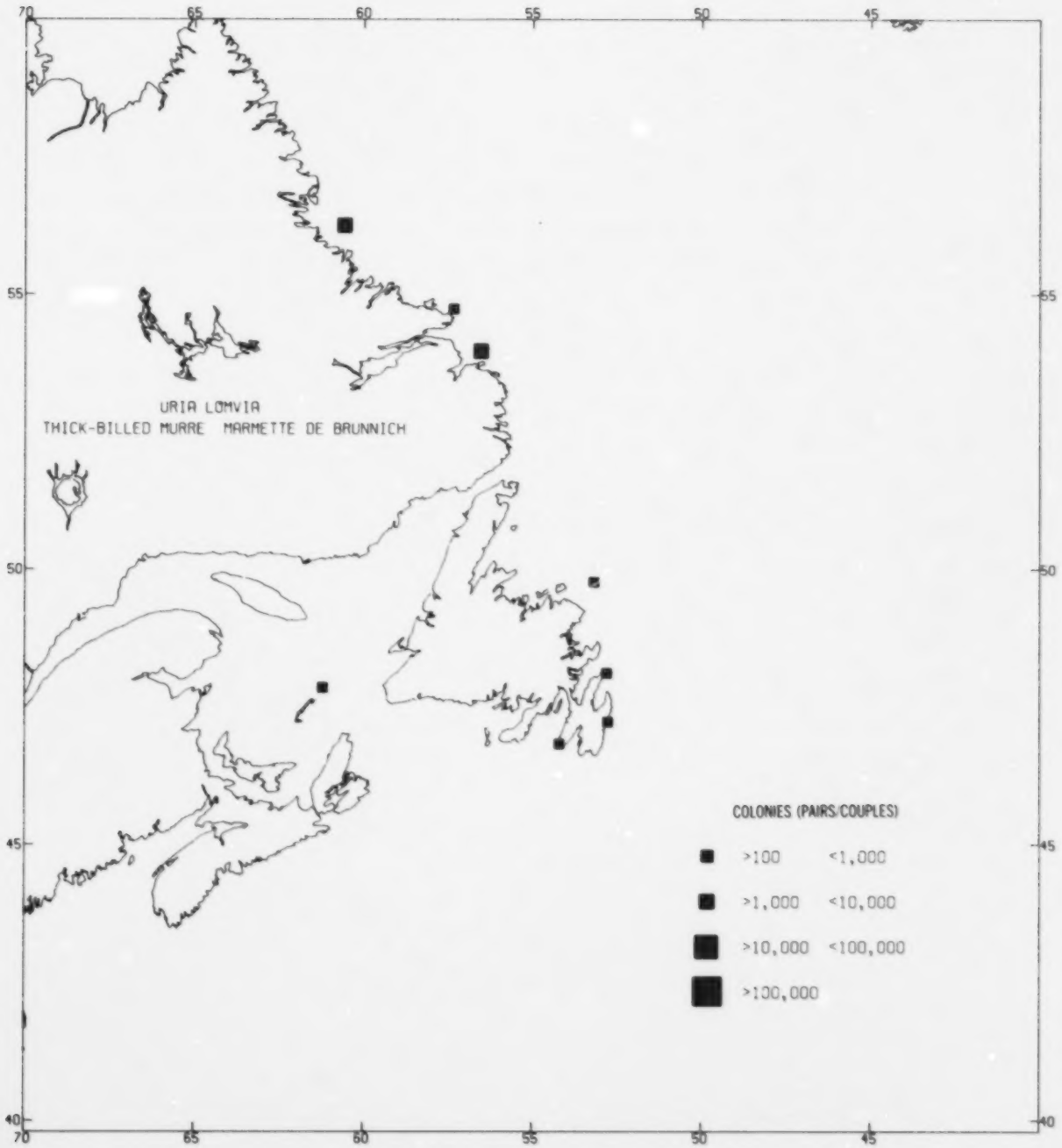
Map 12e
Atlantic, October–December



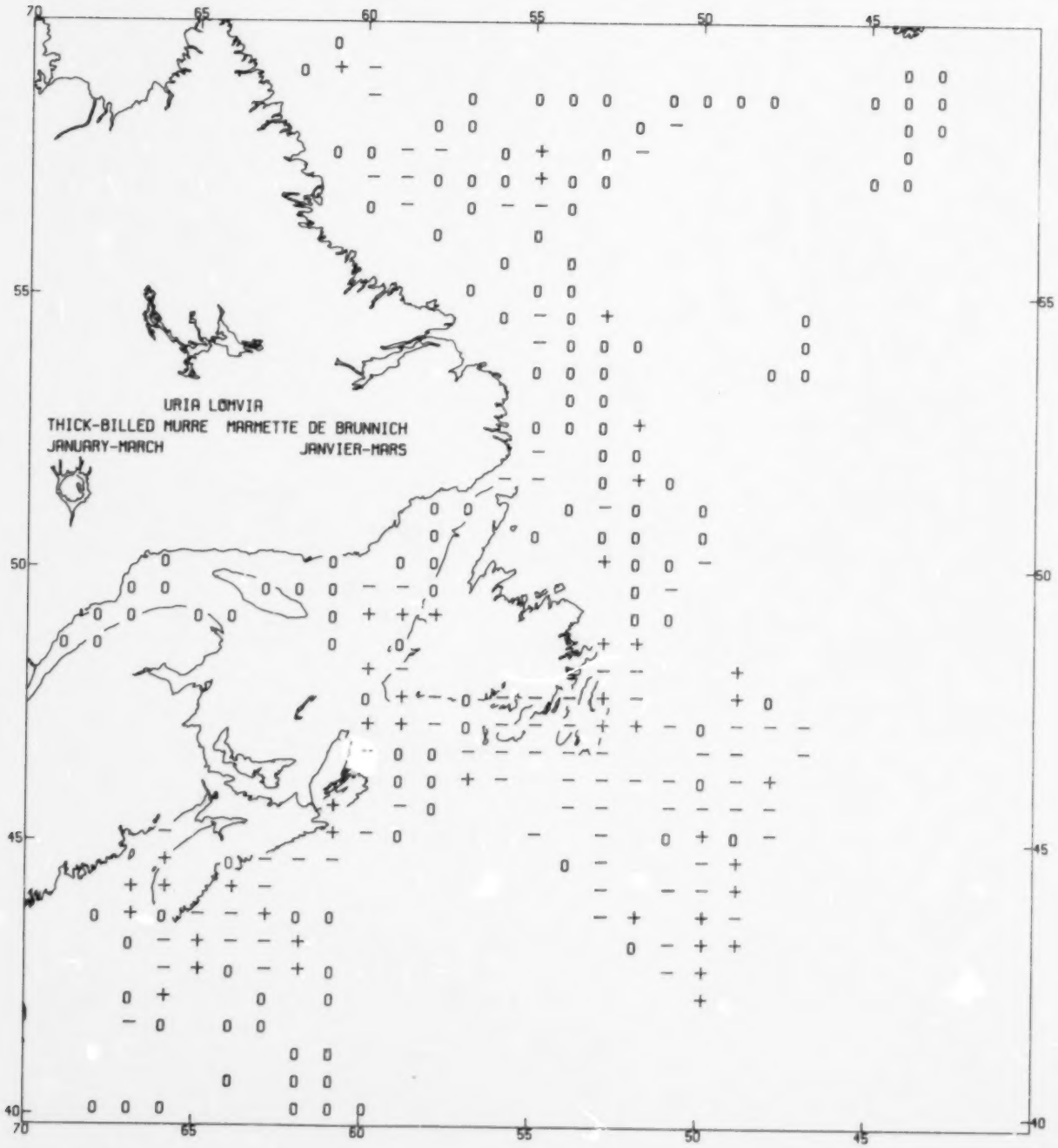
Maps 13a–f

Thick-billed Murre distributions

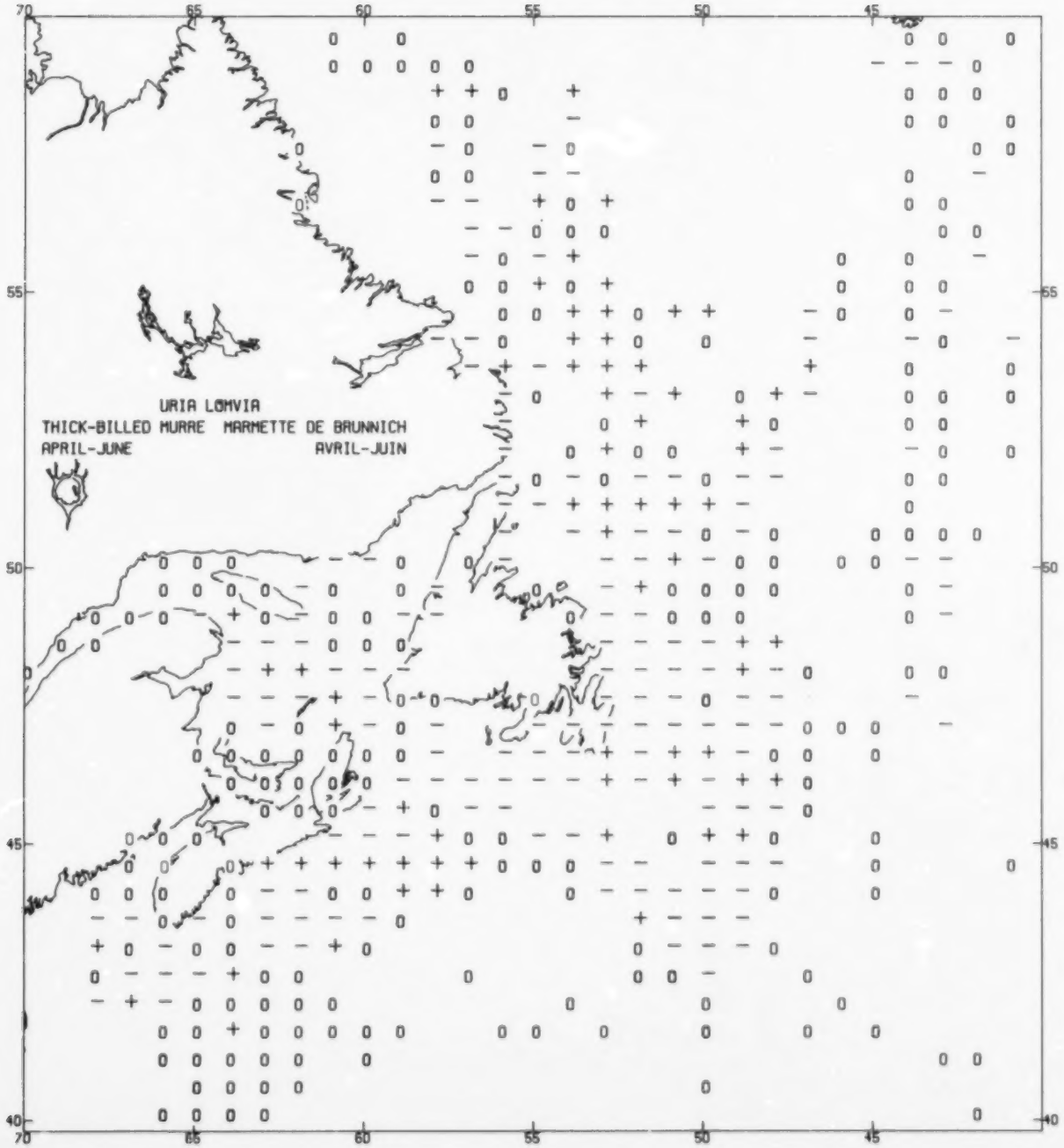
Map 13a
Atlantic colonies



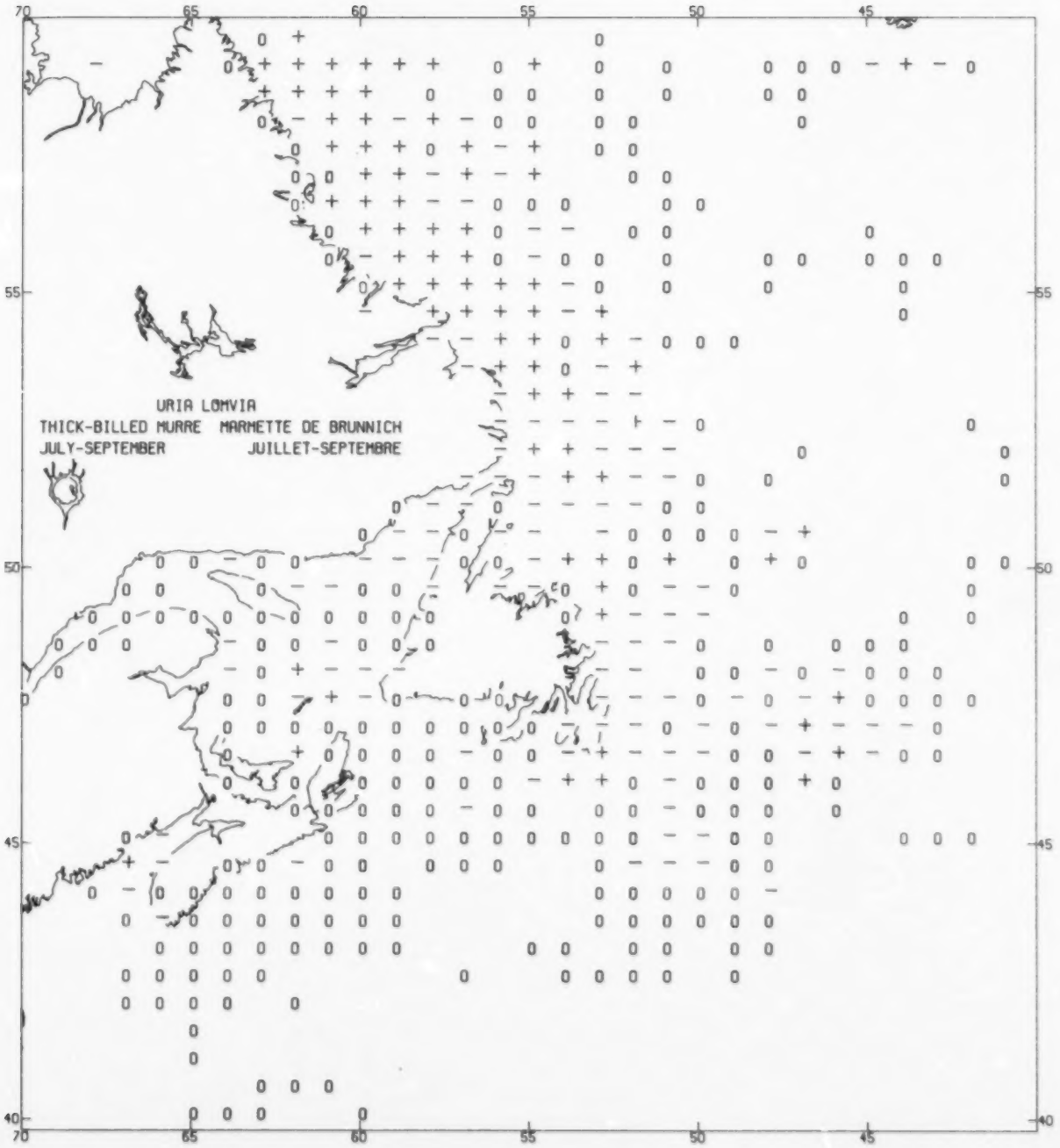
Map 13b
Atlantic, January–March



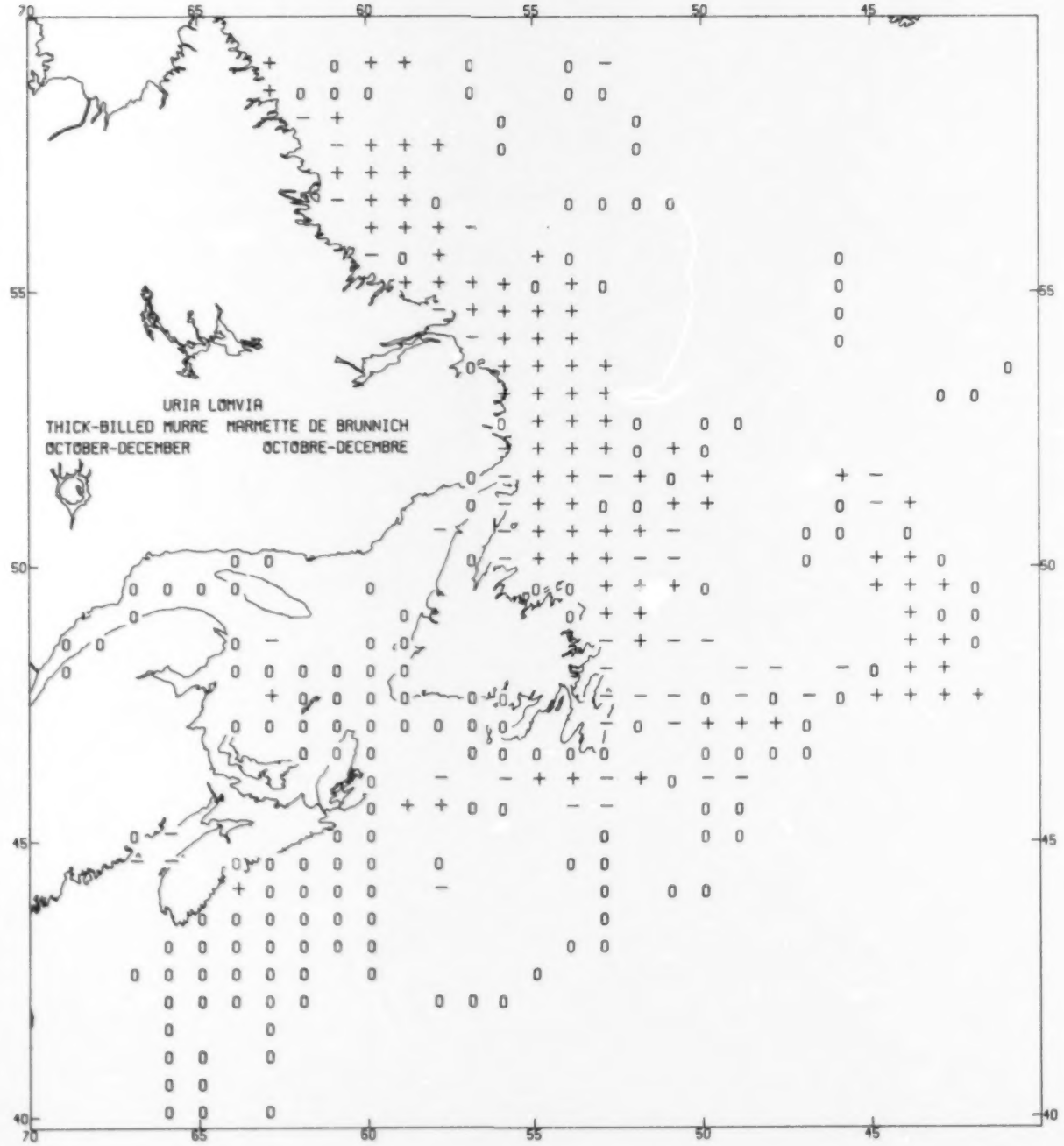
Map 13c
Atlantic, April–June



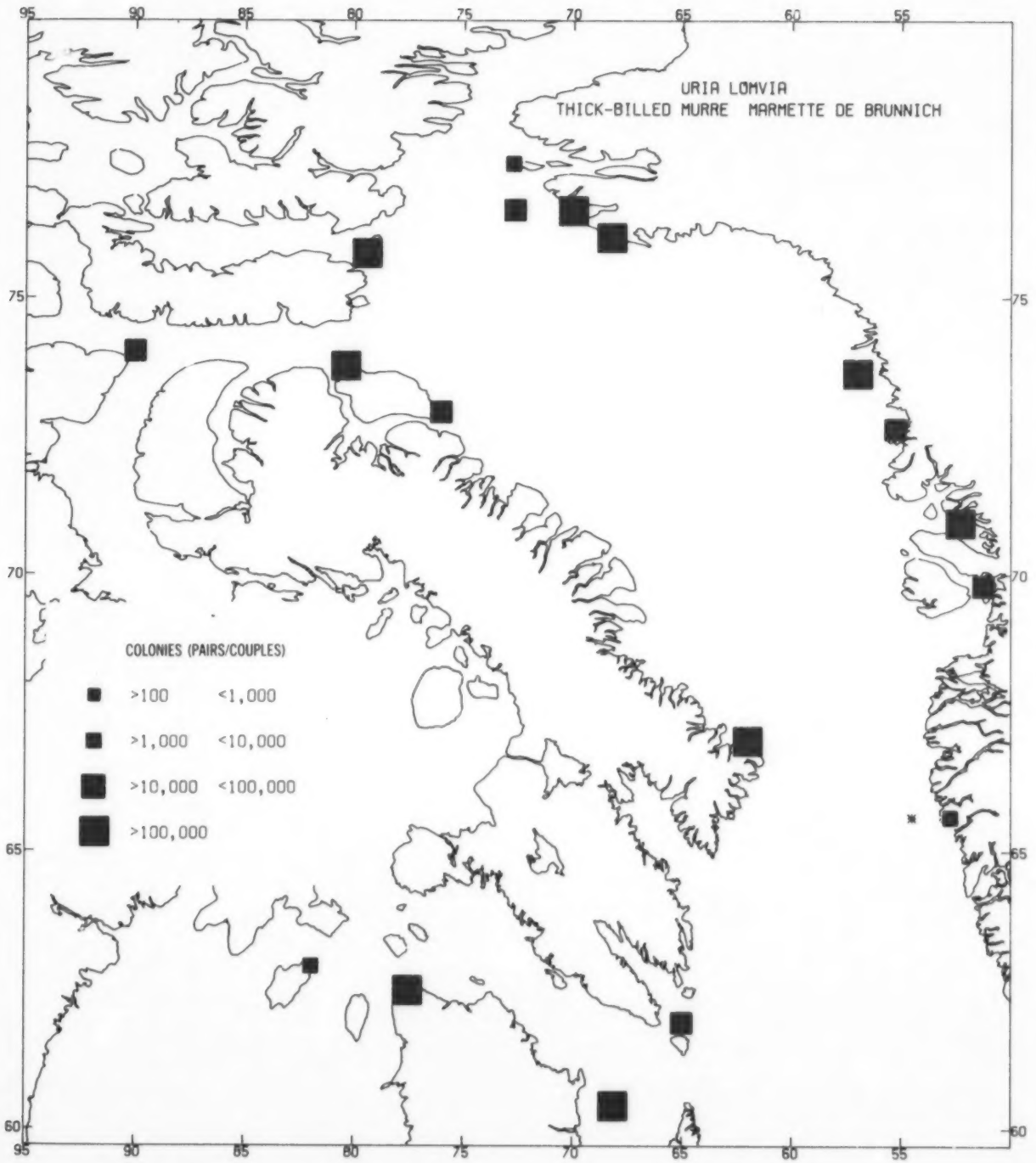
Map 13d
Atlantic, July–September



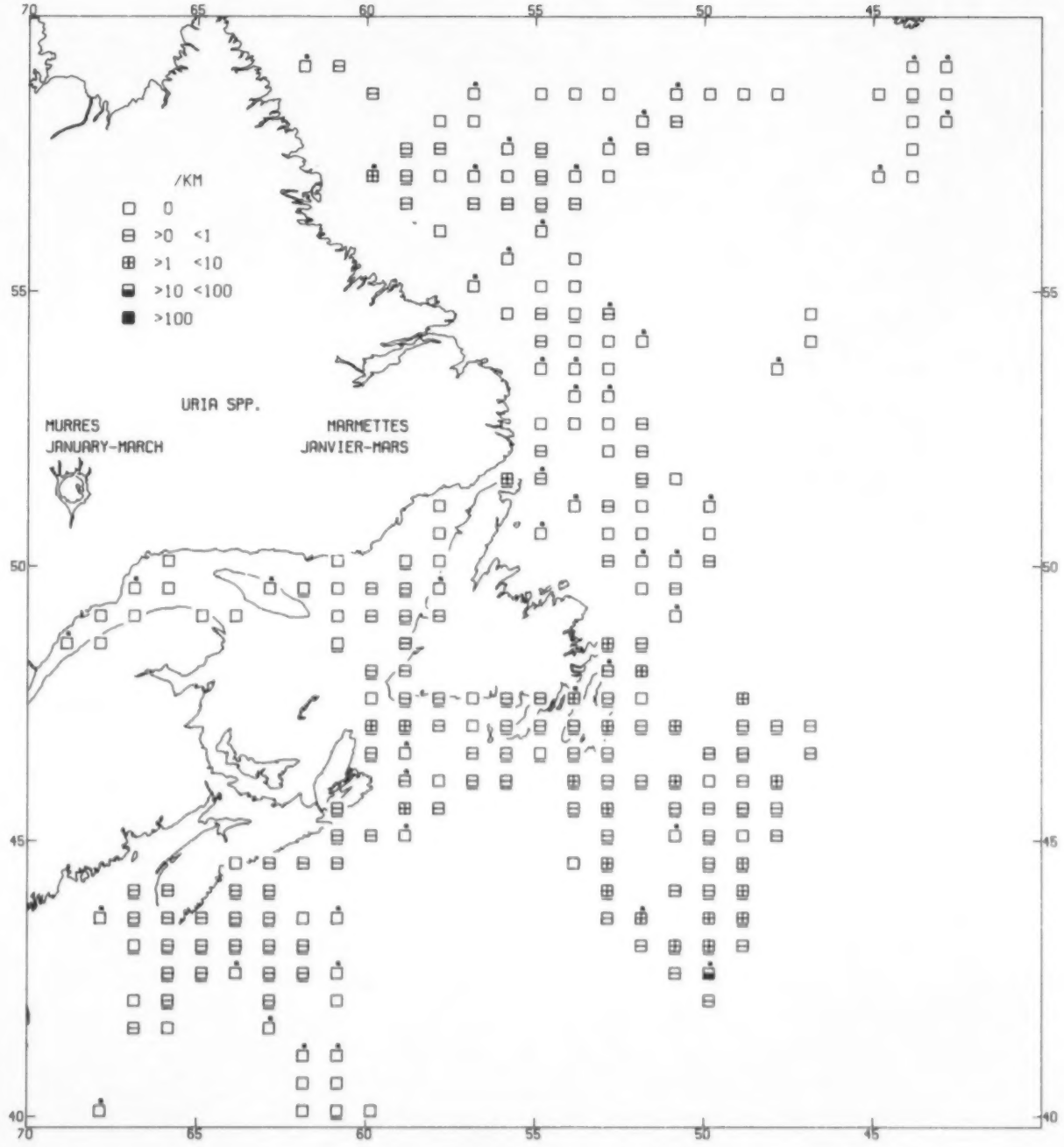
Map 13e
Atlantic, October–December



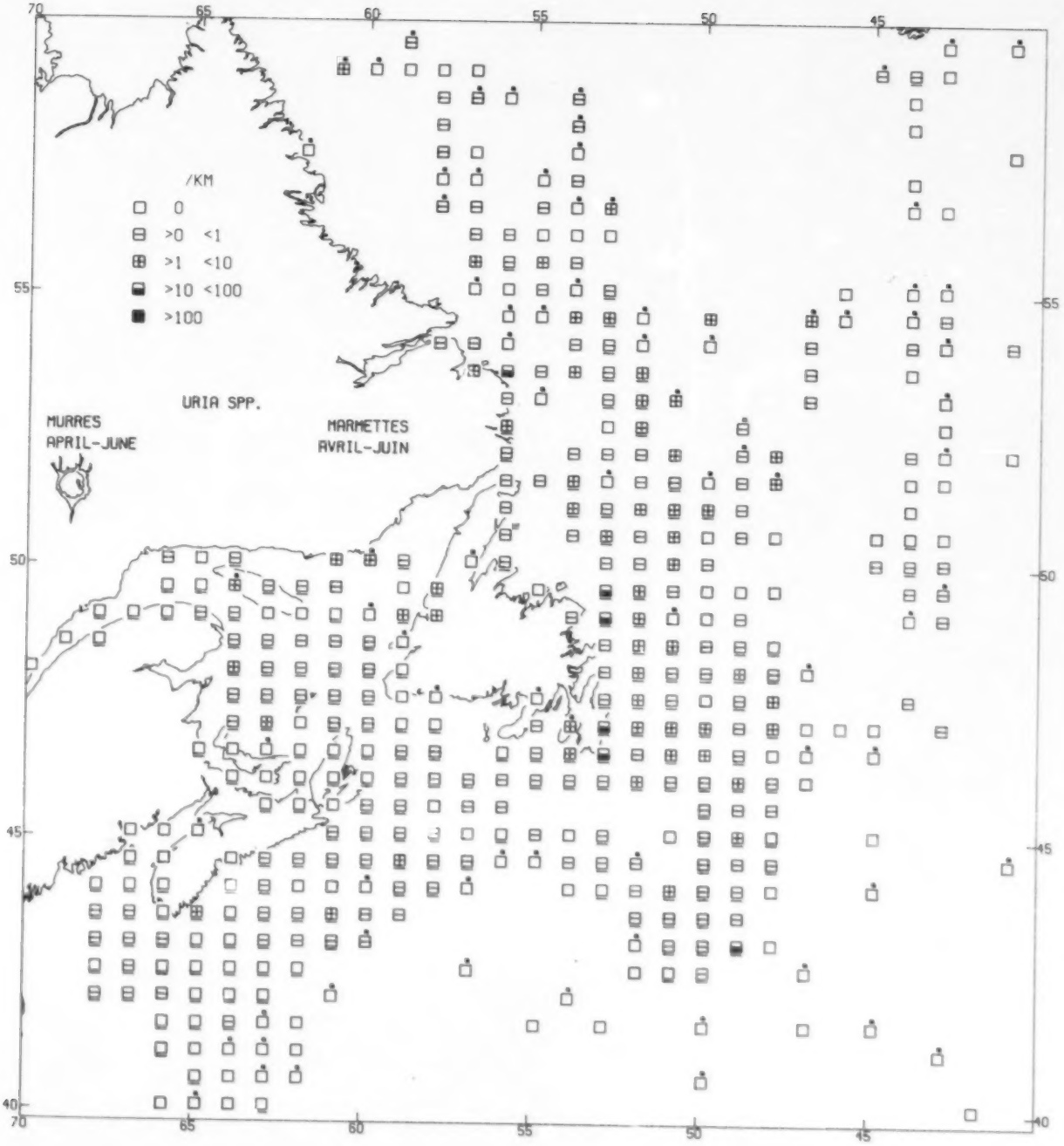
Map 13f
Arctic colonies



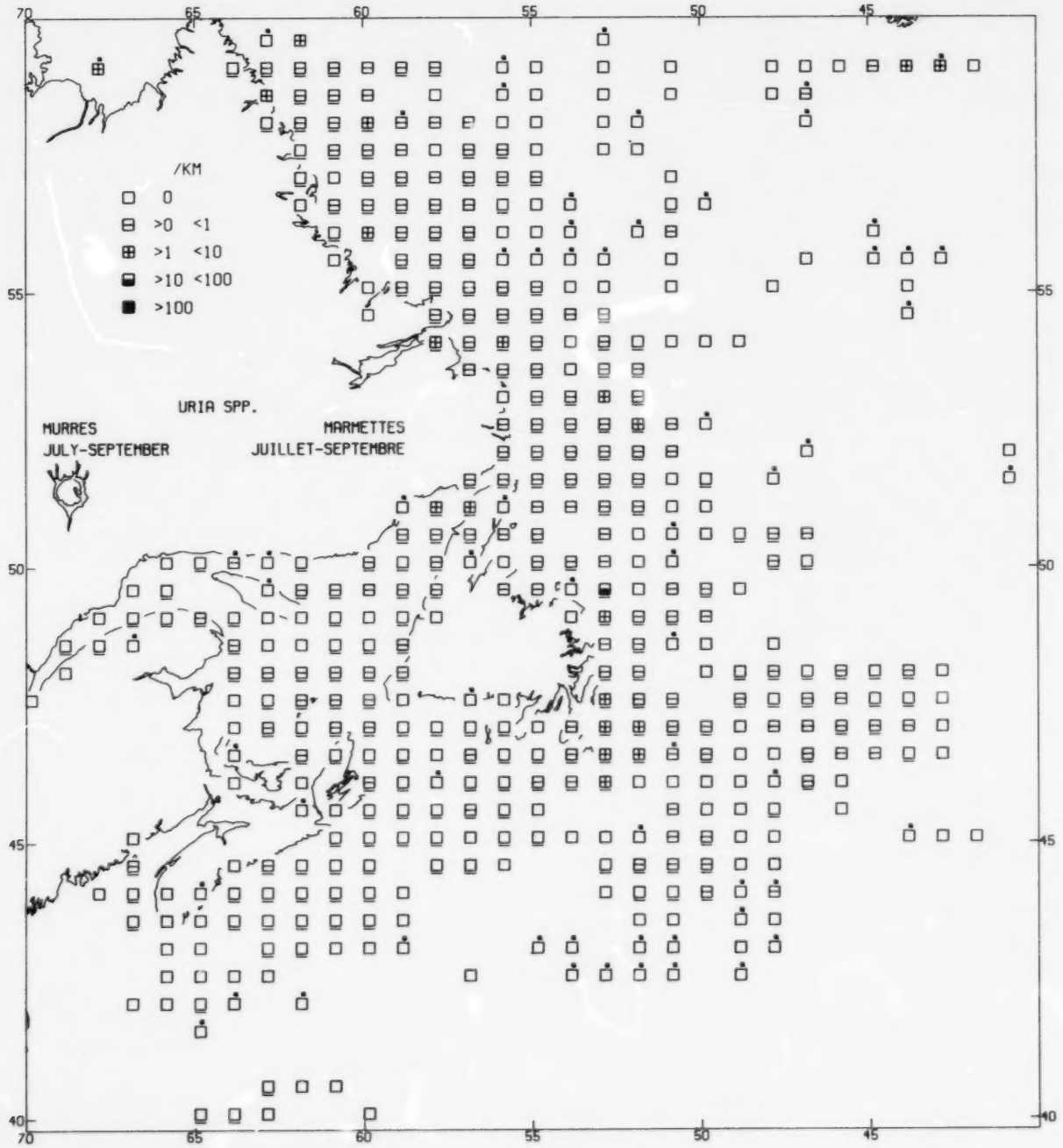
Map 14a
Atlantic, January–March



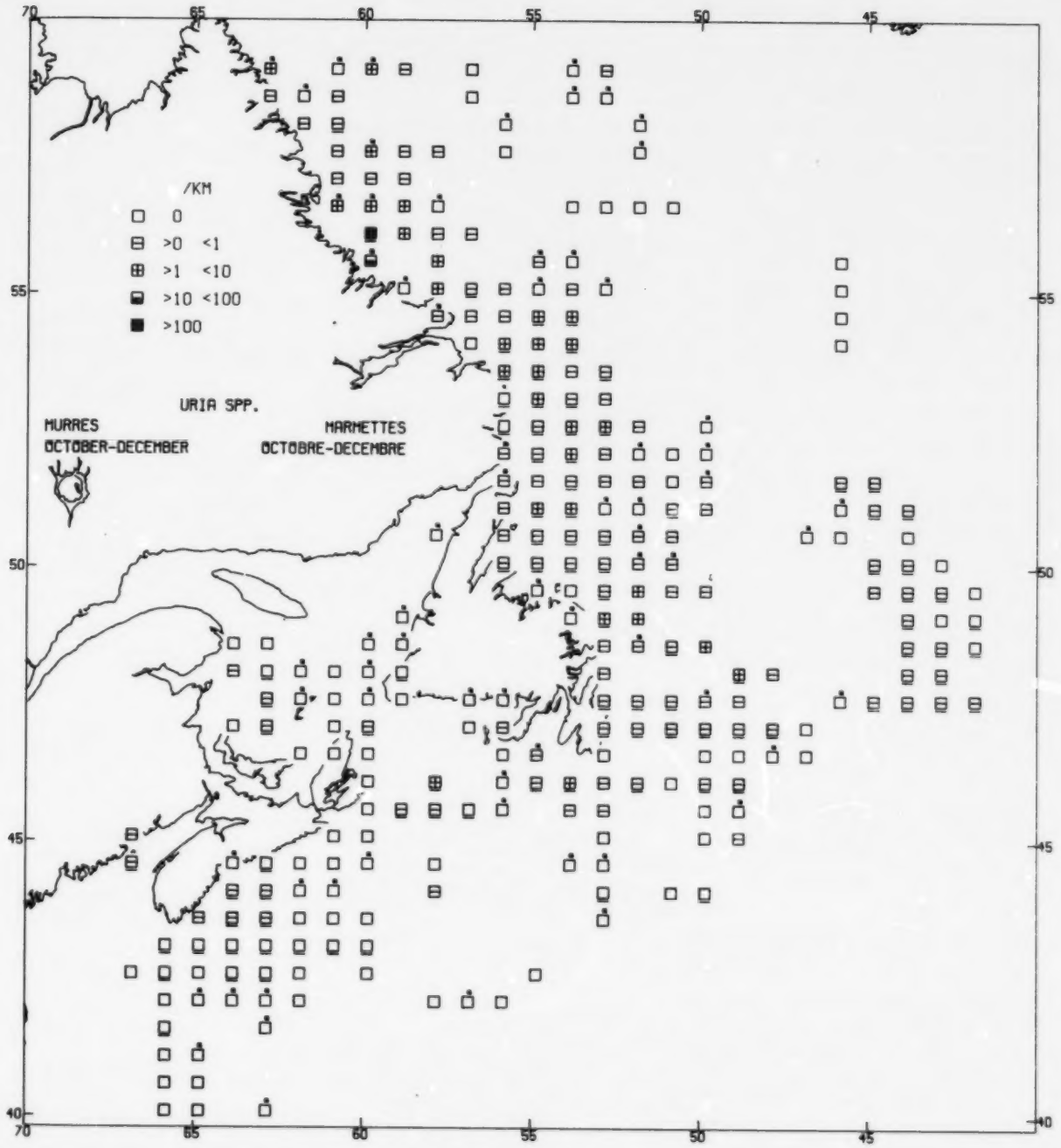
Map 14b
Atlantic, April–June



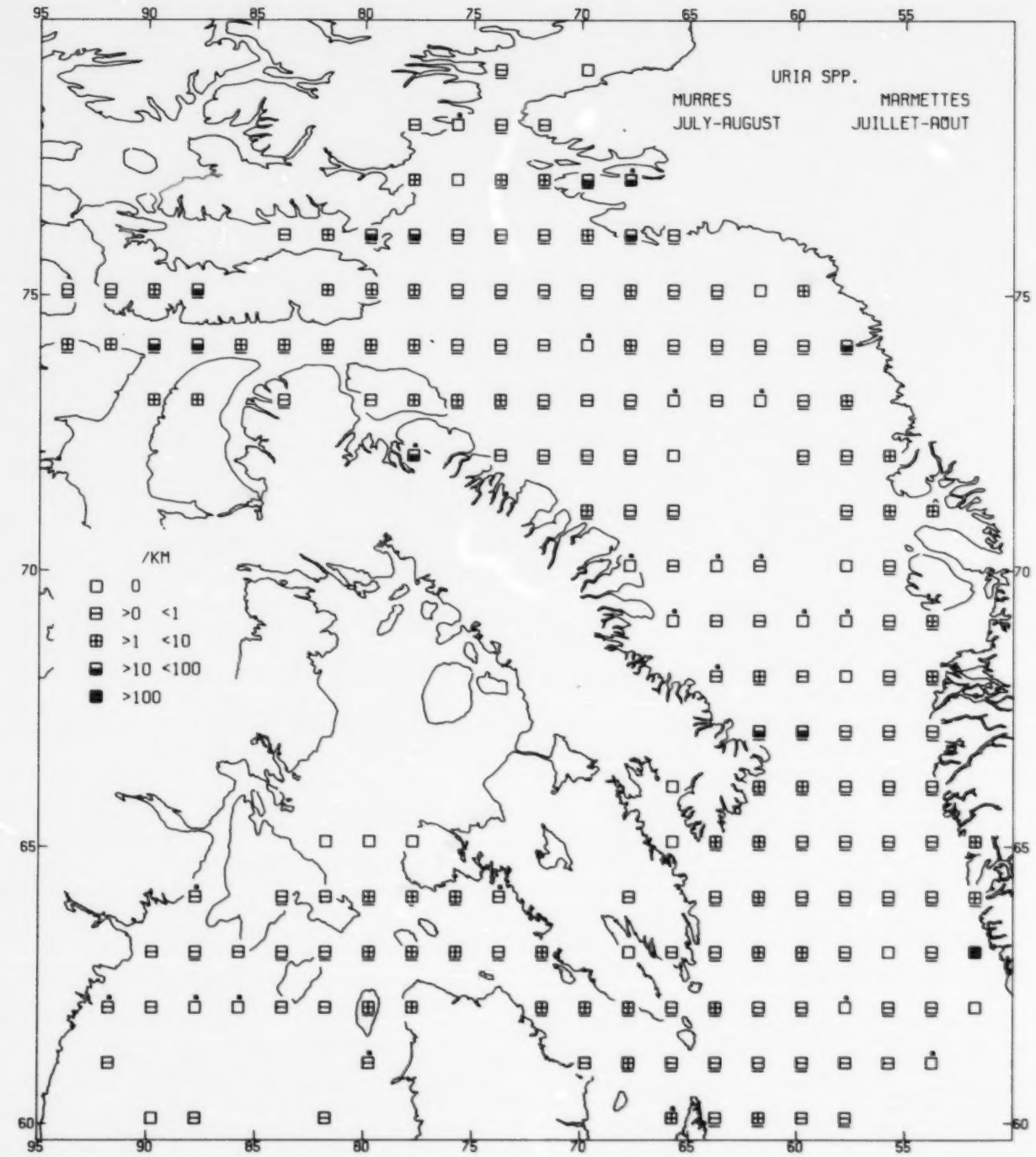
Map 14c
Atlantic, July–September



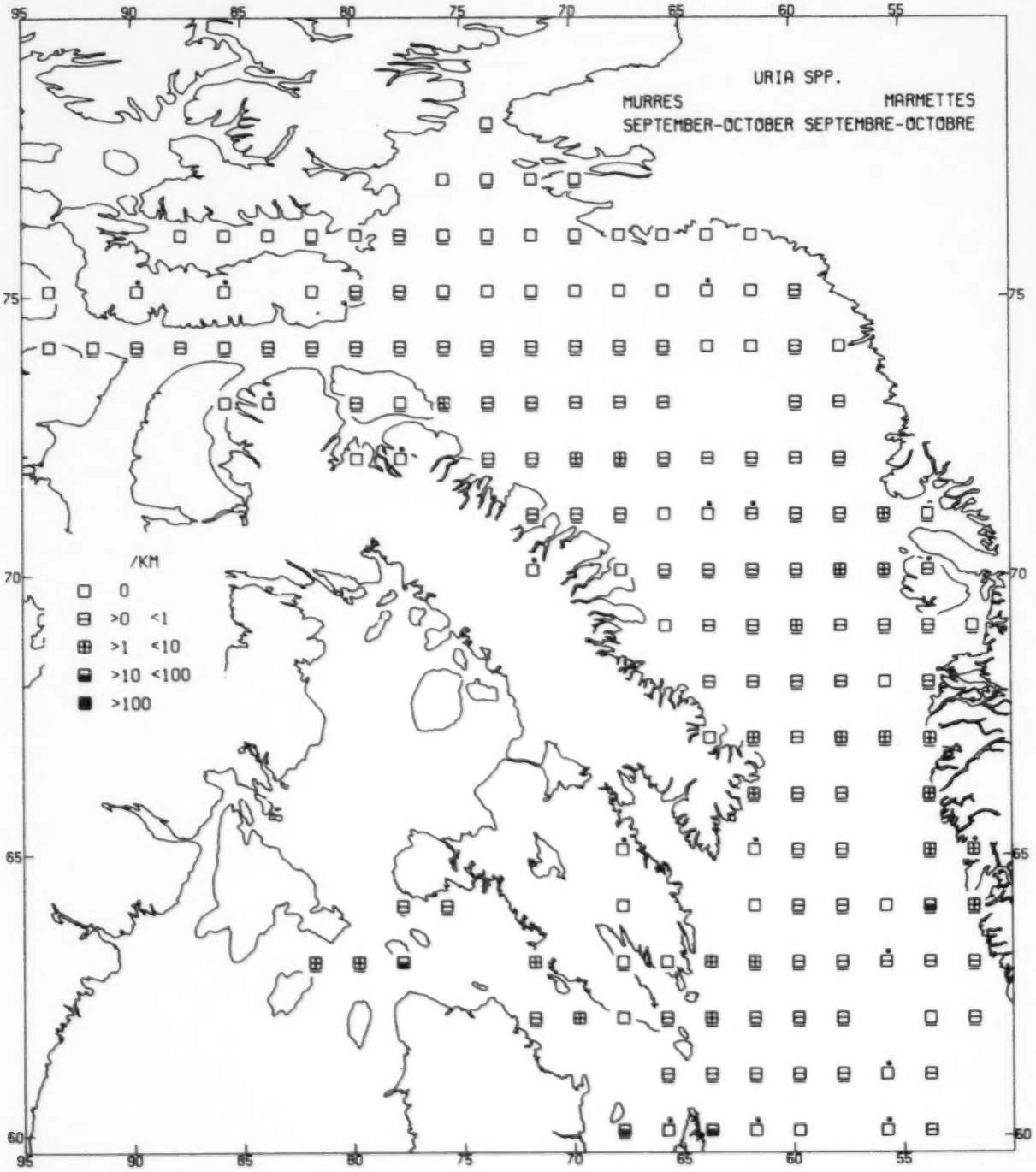
Map 14d
Atlantic, October–December



Map 14e
Arctic, July–August



Map 14f
Arctic, September–October



5.17. Razorbill (*Alca torda*) (Maps 15a–e)

5.17.1. Breeding distribution

The Razorbill breeds only in the Boreal and Low Arctic regions of the North Atlantic. It is one of the rarest of the alcids: the world population is of the order of 400 000 pairs, most of them in the eastern Atlantic. Razorbills breed in Atlantic Canada (c. 20 000 pairs, mainly in southeast Labrador), west Greenland (order 1000), Iceland (order 100 000+), Faeroe (order 5000+), Britain and Ireland (c. 144 000), Brittany (c. 100), Norway (c. 30 000), the Murmansk and White Sea coasts (c. 2200), and the Baltic (c. 5000); there is also a small population on Bear Island (Salomonsen 1950, 1967; Løvenskiold 1964; Joensen 1966; Bianki 1967; Joensen and Preuss 1972; Cramp *et al.* 1974; Brown *et al.* 1975*a*; Lloyd 1976; Norderhaug *et al.* 1977; Chapdelaine and Laporte 1982; Petersen 1982). Map 15a shows the location of the principal Razorbill colonies in Atlantic Canada.

Razorbills arrive on their colonies in west Greenland at the end of April, and lay their single eggs in mid-June; laying begins 2 weeks earlier in Canadian colonies (Salomonsen 1967, Bedard 1969). Like the young murres (q.v.), Razorbill chicks leave their colonies before they can fly, and swim off accompanied by a parent. The colonies are abandoned in mid-August.

5.17.2. Pelagic distribution

(*a*) General

Observations and the scanty banding returns suggest that the population of Razorbills breeding in Atlantic Canada probably winters in the Gulf of Maine and on Georges Bank, with stragglers as far south as North Carolina (c. 35°N) (Rowlett 1973, Lee and Booth 1979, Powers 1983.) Razorbills were killed by oil from the wreck of the *Argo Merchant* off New England between December 1976 and January 1977 (Powers and Rumage 1978), but the species is rarely a victim of winter oil spills farther north, off Nova Scotia and southern Newfoundland (Tuck 1961, Brown *et al.* 1973*a*, Brown and Johnson 1980). Most Razorbills disappear from Greenland waters in mid-September, and probably move to Canadian Atlantic waters (Salomonsen 1967). However, a few birds winter off southwest Greenland. Some of these are migrants from the eastern Atlantic: a bird banded in the White Sea was recovered in southwest Greenland in January (Bianki 1967).

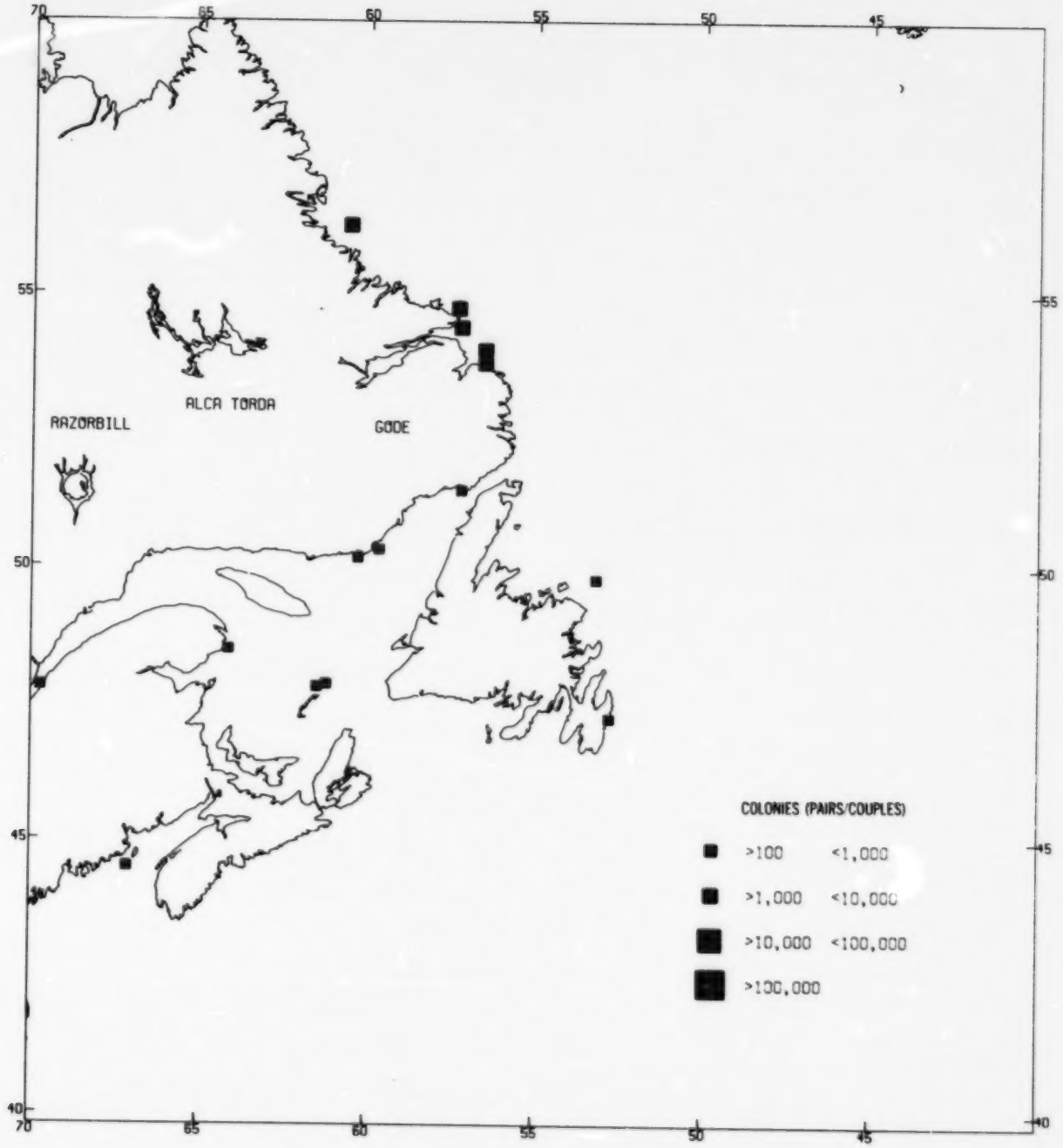
(*b*) *Atlas* maps: Atlantic

Because of the difficulty of separating Razorbills from murres at sea, their Atlantic distribution maps are presented in the same "+/−/o" format (see above). The *Atlas* files include no Arctic records of Razorbills.

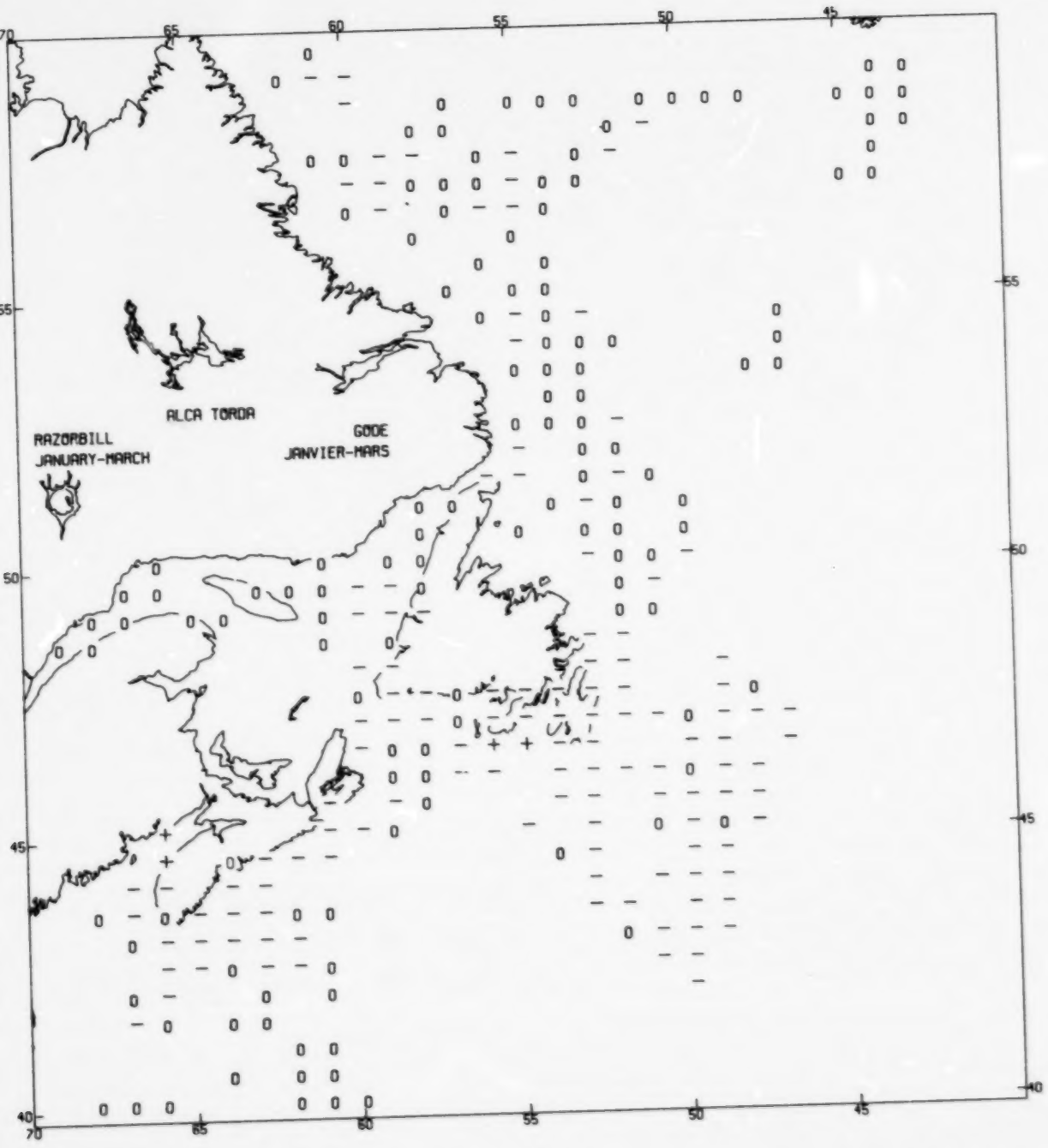
Small numbers of Razorbills occur on Georges Bank and inshore in January–May; their usual southern limit is c. 41°N, though there are stragglers farther south (Powers 1983). The *Atlas* maps show that the species is present off southern Nova Scotia, and to a lesser extent off southern Newfoundland, in January–March. Razorbills are regularly seen in the Bay of Fundy all summer. They occur off southeast Labrador in June (and probably earlier), and they are fairly widely distributed on the Labrador Shelf in July–August — presumably as the birds disperse from their colonies on the adjacent coast after breeding is finished. A few Razorbills remain off southeast Labrador as late as November and December, and there are birds on Georges and the Grand Banks and in the Bay of Fundy at that time.

Maps 15a–e
Razorbill distributions

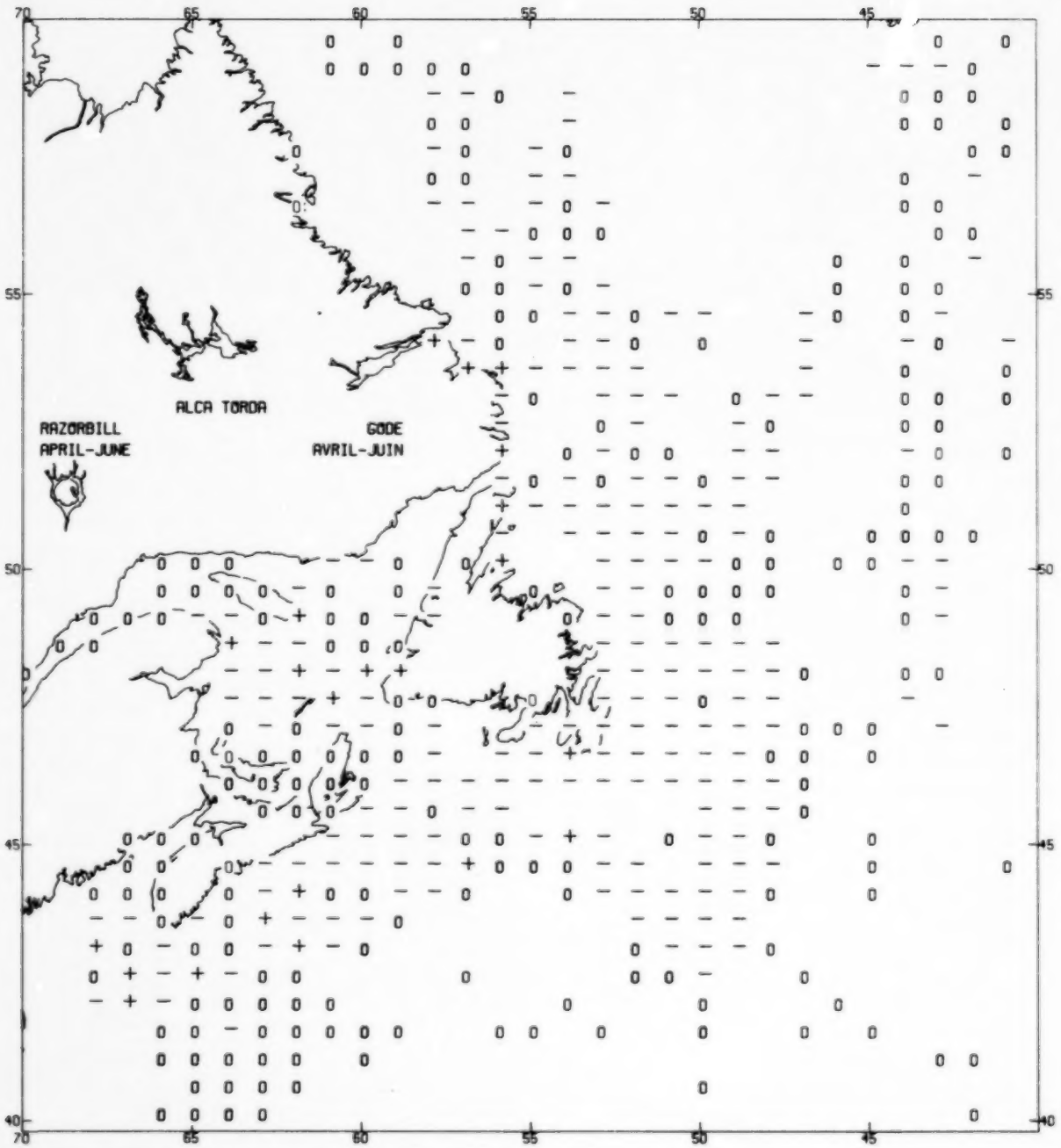
Map 15a
Atlantic colonies



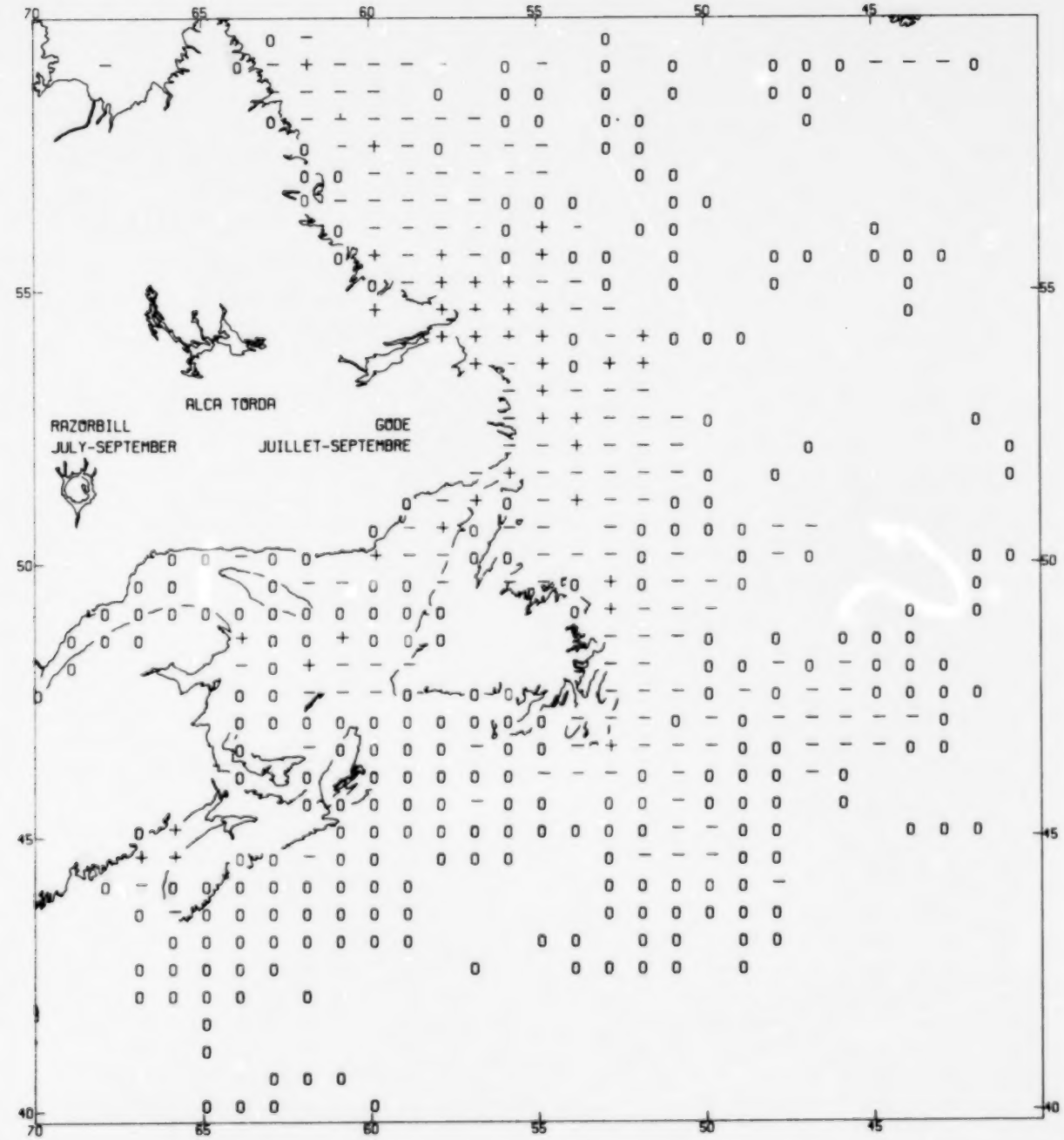
ap 15b
tlantic, January–March



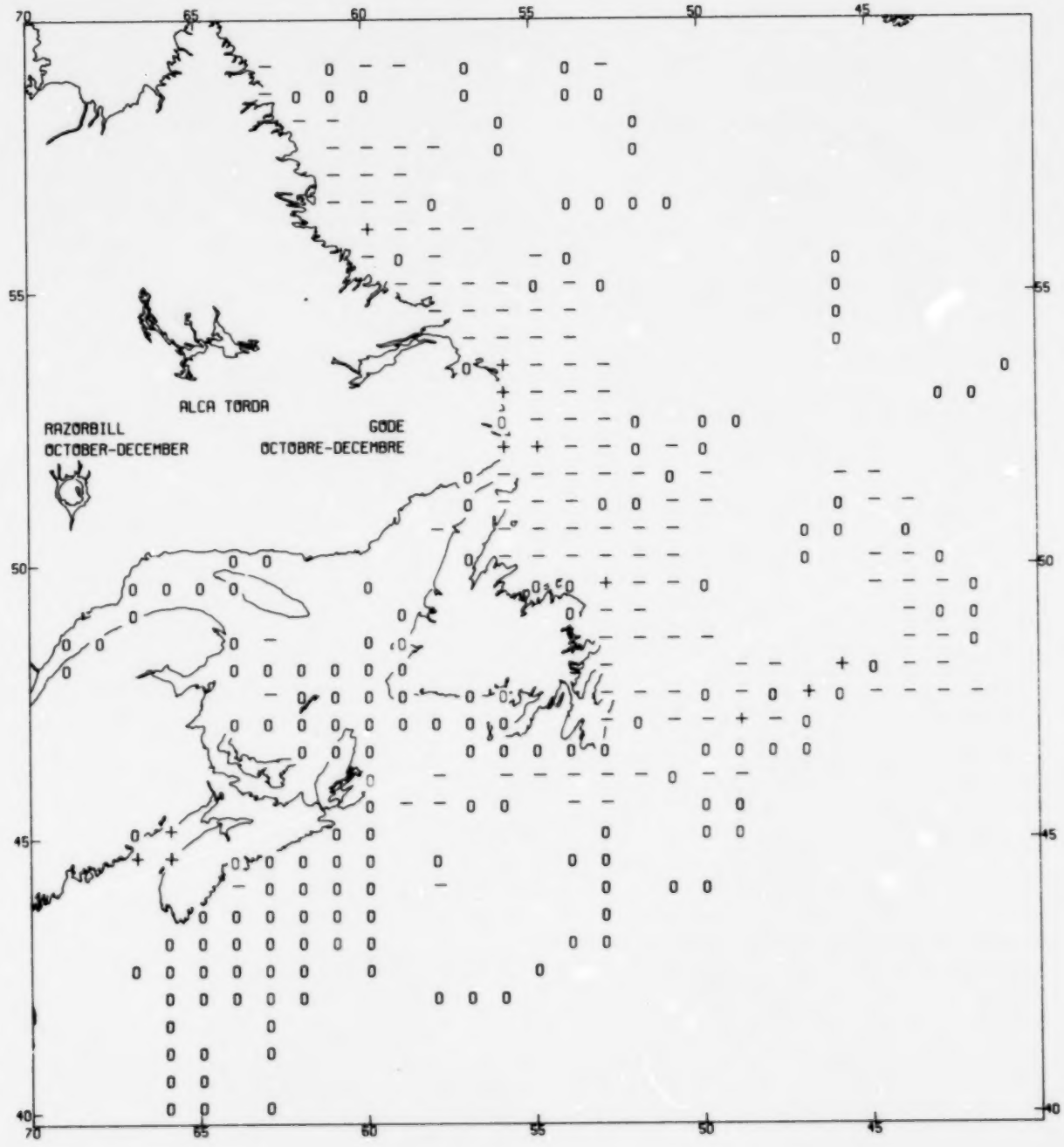
Map 15c
Atlantic, April–June



Map 15d
Atlantic, July–September



Map 15e
Atlantic, October–December



5.18. Atlantic Puffin (*Fratercula arctica*) (Maps 16a–c)

5.18.1. Breeding distribution

Atlantic Puffins occur only in the North Atlantic, where their population is of the order of 12 million pairs. They breed in Atlantic Canada (c. 320 000 pairs, mainly in southeast Newfoundland), Hudson Strait (<1000), west Greenland (order 1000+), Iceland (order 8–10 million), Faeroe (order 500 000+), Britain and Ireland (c. 550 000), Norway (c. 1.25 million), Svalbard (order 10 000), and the Murmansk coast (c. 16 000). There are also small populations in Brittany, Jan Mayen, and Novaya Zemlya (Salomonsen 1950, 1967; Fisher and Lockley 1954; Joensen 1966; Joensen and Preuss 1972; Cramp *et al.* 1974; Brown *et al.* 1975*a*; Harris 1976; Norderhaug *et al.* 1977; Gaston 1982; Petersen 1982.) The locations of the principal colonies in Atlantic Canada are shown in Map 16a.

Puffins return to their colonies in Newfoundland in late April and lay their single eggs, in burrows in the turf, in mid-May. The young hatch in late June and early July, and begin to fledge in mid-August, though late chicks remain until early September (Nettleship 1972). West Greenland birds return in early May and lay in mid-June, and their chicks fledge around the beginning of September (Salomonsen 1967).

5.18.2. Pelagic distribution

(*a*) General

The pelagic distribution of puffins is not well known. This is probably because they are widely dispersed and well offshore outside the breeding season. The birds' habit of diving rather than flying up at the approach of a ship makes it hard to see them at sea. Extensive banding at puffin colonies in the eastern Atlantic shows that these birds tend to move south in winter; the youngest travel furthest, and many reach the Mediterranean (Mead 1974, Brown 1985). On this analogy one would expect birds breeding in Atlantic Canada to move south as well, but there are not enough banding recoveries to reveal any obvious pattern of movements. However, banding has shown that many juvenile puffins from the eastern Atlantic move to eastern Newfoundland waters in the fall; Tuck (1971) listed 18 recoveries there of birds banded in southwest Iceland, as well as two from Scotland and one from west Greenland, mainly in October–December. Juveniles from Scotland and northern Norway have also been recovered off southwest Greenland in November–January (Salomonsen 1967).

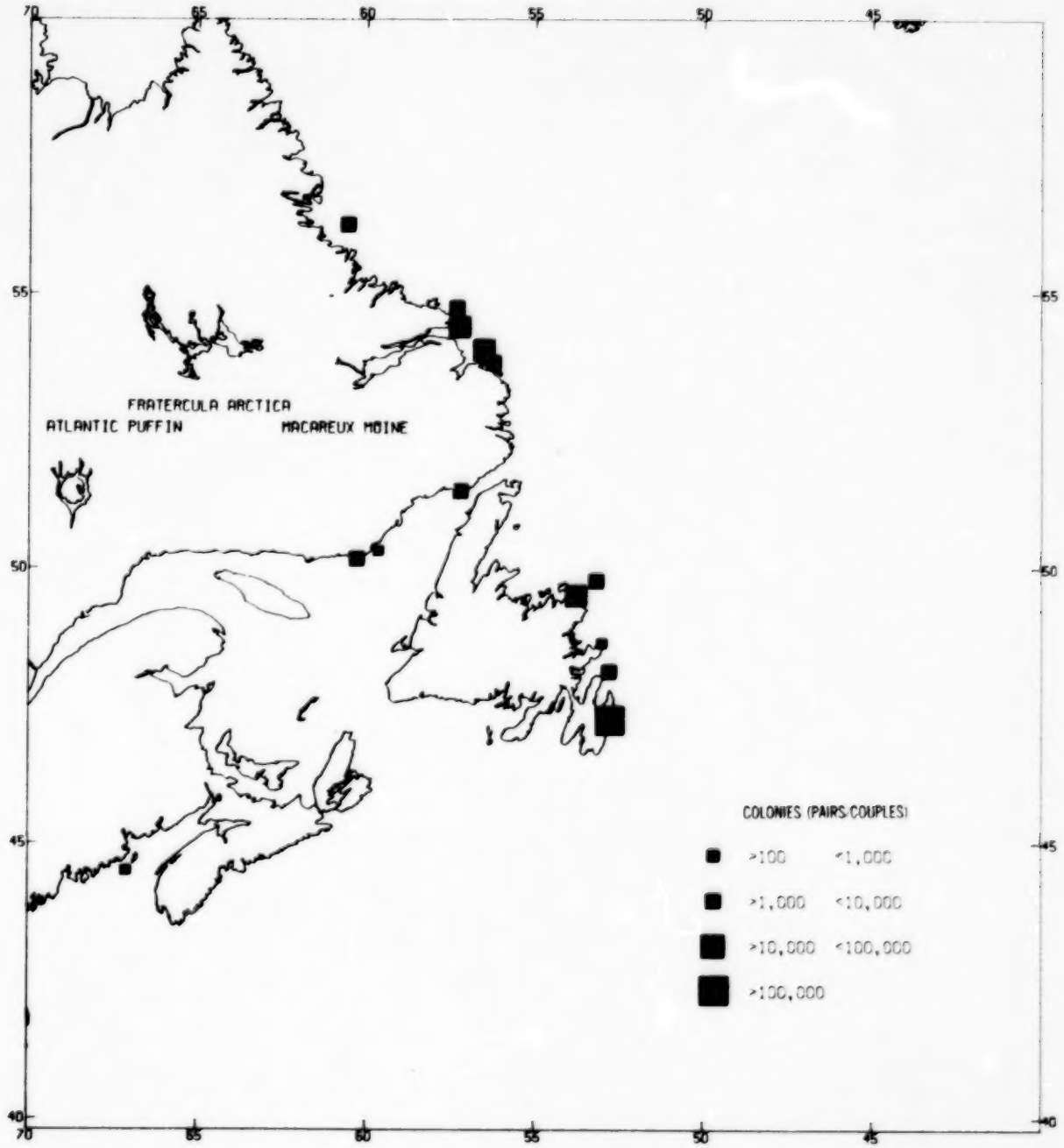
(*b*) *Atlas* maps: Atlantic

Puffins are found in very small numbers at the shelf-break on eastern and northern Georges Bank in January–May (Powers 1983). Occasional birds are seen on the southern Grand Bank and south of Nova Scotia in January–March (Brown *et al.* 1975*a*). The *Atlas* maps show a few birds in the south of our survey area in April–June, but most sightings are close to the very large colonies in southeast Newfoundland and on the adjacent part of the northern Grand Bank. They remain common off southeast Newfoundland in June–September, but are closer inshore — presumably within economical foraging range of their colonies. Puffins have reached southeast Labrador by June, and birds are widely dispersed in small numbers over the Labrador Shelf in July–September. There are few puffin sightings in October–December. However, the birds appear to leave Labrador waters in October, and most of the fall records are off northeast Newfoundland. Scattered birds remain on the northern Grand Bank in November–December, and also along the front, east of Flemish Cap, between the *Labrador Current* and the *North Atlantic Drift* (R.G.B. Brown, in prep.). Puffins return to Georges Bank in December (Powers 1983).

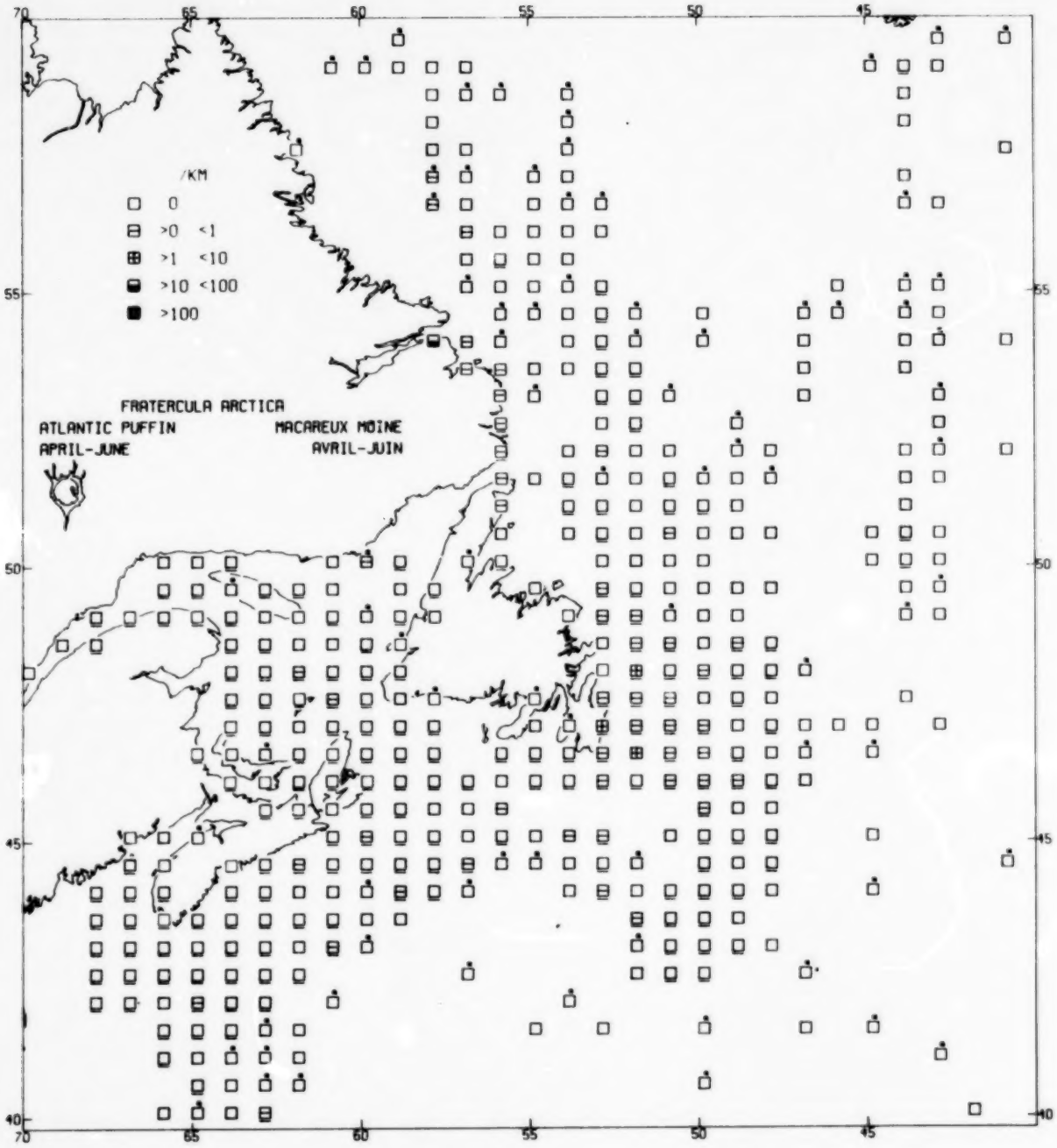
There are very few Arctic sightings of Puffins in the *Atlas* files. Brown *et al.* (1975*a*) showed that birds are widely dispersed in Davis Strait in August, reaching c. 69°N on the Greenland coast, but that the northern limit retreats to c. 64°N in September.

Maps 16a–c
Atlantic Puffin distributions

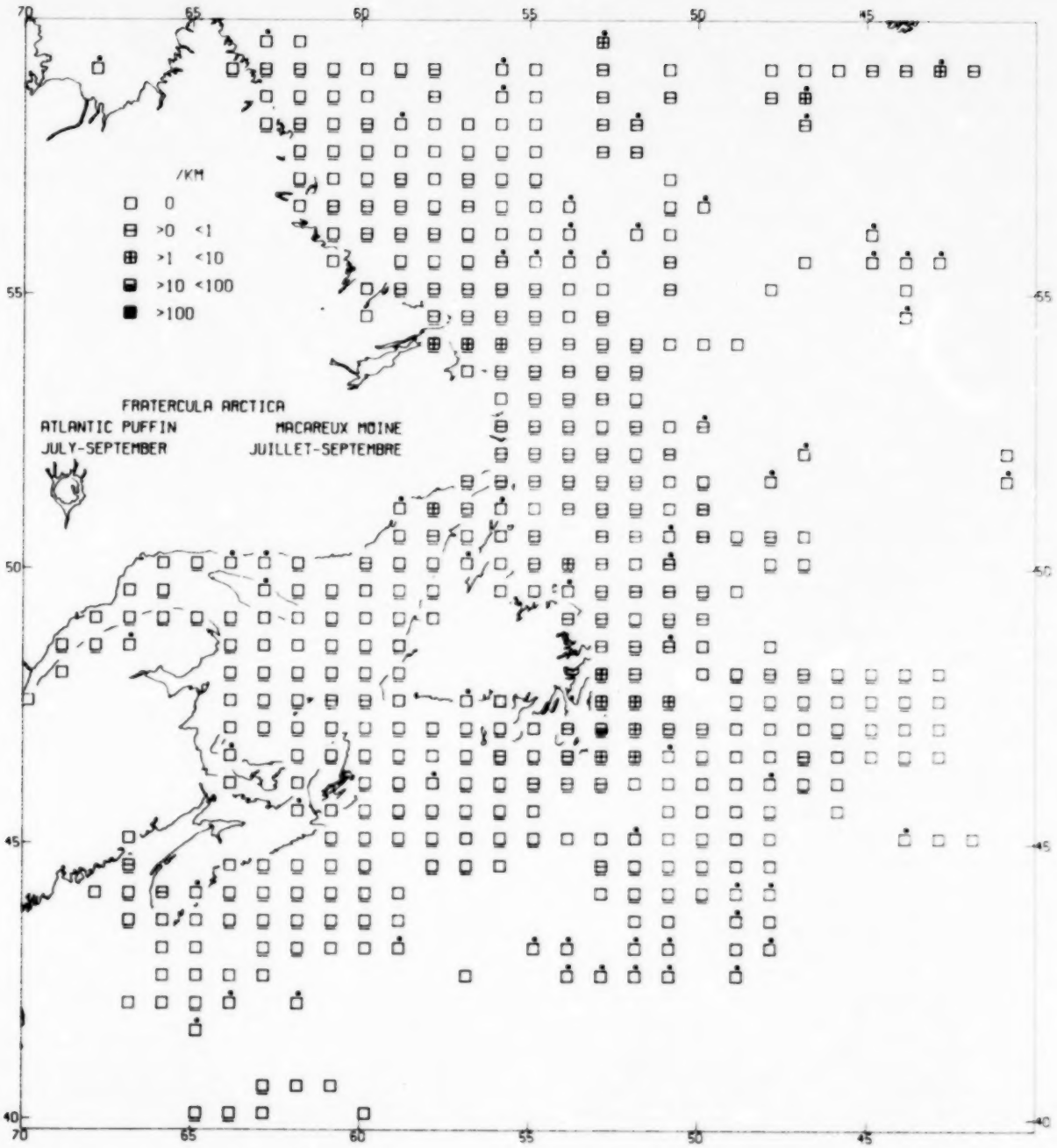
Map 16a
Atlantic colonies



Map 16b
Atlantic April–June



Map 16c
Atlantic, July–September



5.19. Black Guillemot (*Cepphus grylle*)

The Black Guillemot occurs inshore along rocky coastlines in both the Nearctic and Palaearctic. It breeds around the whole of the Arctic Ocean basin, south to James Bay, southern Greenland and Maine in the western Atlantic, and to southwest Ireland and the southern Baltic in the east. It is replaced by the sibling species *C. columba* and the related *C. carbo* in the North Pacific (Salomonsen 1950, 1967; Storer 1952; Fisher and Lockley 1954; Godfrey 1966; Cramp *et al.* 1974).

There are no estimates of total Black Guillemot numbers in the *Atlas* survey area, but the New England population is of the order of 4000 pairs (Drury 1973–74). The species is only weakly colonial as a rule, but large breeding associations occur at some Canadian High Arctic locations: c. 17 000 pairs in western Jones Sound (c. 76°30′N, 89°40′W), and c. 4000 on Prince Leopold Island, Lancaster Sound (74°02′N, 90°00′W) (Nettleship 1974, Nettleship and Smith 1975).

Black Guillemots may occur well offshore in winter at the edge of the pack-ice (Renaud and Bradstreet 1980; A.J. Gaston, CWS, pers. commun.). They are seldom seen far from land at other times of year, however, and their summer pelagic distribution is virtually the same as their breeding range. Banding shows that after the young leave the nest in August they tend to disperse with the prevailing currents — north up the west coast to Greenland and west along the north shore of the Gulf of St. Lawrence (Salomonsen 1967, CWS banding files). This is not simply a passive drift, because the birds are able to fly. The west Greenland birds move south again later in the fall, and most of the population winters in the ice-free areas south of c. 69°N. Young birds from northwest Greenland have been recovered in spring in Hudson Strait and Salomonsen suggested that these migrate southwest along the edge of the pack-ice in western Baffin Bay. Birds banded in western Iceland have been recovered in winter in southwest Greenland, and Petersen (1977) believed that a significant fraction of the Icelandic population makes this migration. Banding also shows a tendency for some Atlantic Canadian Black Guillemots to move down to New England waters, though others overwinter along our coasts (NSBS 1971–84, CWS banding files).

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